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TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

V. 9-10

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NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

THE COMMERCE OF SAN FRANCISCO.

No. II.

BY GEORGE W. DICKIE, MEM. TECH. SOC.

[Read Jan. 7, 1892.]

The Secretary, on behalf of the Technical Society, having written me to ascertain if I would be willing to read and discuss before you my recent publication on the "Commerce of San Francisco," I suggested that the pamphlet having already received some attention from the newspapers and the merchants, it would be better for me to assist the further discussion of this important subject by meeting the various objections and criticisms that have been sent me direct, or have appeared in the press.

In order to clear the atmosphere of anything personal, and enable us to meet the technical difficulties that have been raised to the establishment of a direct ocean steamship line from this port to New York and Liverpool, in their proper order, I will dispose first of the objections that have been raised against the parentage of this scheme. Suspicion lurks in some quarters, because the proposition for a steamship line comes from an engineer and a shipbuilder interested in a company which is supposed by these objectors to be backed by the railroad monopoly. If San Francisco desires an outlet for her products, and an entrance for her imports by her own Golden Gate, who are most likely to give sound advice as to the best instruments by which this desired result is to be accomplished? Is it not

those men who have given a life study to problems involved in the successful production of a modern ocean steamship?

The most successful steamship lines are those which keep on very intimate terms with the shipbuilder. If we want to dress well we take advice from our tailor in regard to the style of dress that will best suit us. If we want to erect a great building, that will be an honor to the City, we consult an architect who has had experience, and we carefully study the plans he proposes. So if the merchants of this City desire to make it the entry port for the western side of the United States, it can only be done by building a line of modern freight steamships expressly built for the special requirements of the trade, and, to do this, you need advice from your shipbuilders and engineers, so that, I think, we may take it for granted that the County Line comes from a poor, but honest and industrious parent.

In regard to the suspicion as to the place of its birth, it was natural for the newspapers to link my name with that of the Union Iron Works, although I expressly stated in my pamphlet that my work was that of an individual only. Nor need any suspicion be engendered on that account. Any statement made as to the connection of any of the Southern Pacific railroad people with the Union Iron Works Company has no foundation in fact. If the Union Iron Works has secured a good standing among the business concerns of this Coast, and among the shipbuilders of this country, it has not been by any backing from the outside, but is the result entirely of hard work and honest endeavor on the part of the Messrs. Scott and their associates.

Now, we will devote our attention to the "County Line," and why such ships were proposed. We will consider first the ships themselves, and second, the operating of them.

The question has been raised, both by letter and in the newspapers, why these vessels are proposed of such a size? In answering this question, I will not be tempted into discussing the steamship proposition of The Johnson-Locke Mercantile Company further than to notice one technical point, that has been presented in such a way as might lead to a misunderstanding. Having gone carefully through the specifications of their proposed vessel, I would not be justified in letting it pass unnoticed. I refer to the carrying capacity. Mr. Johnson (whom, by the way, I have not met) gives the carrying capacity of the vessel he proposes at 4,000 tons. Now the dimensions of the vessel, as specified, give a total dead weight carrying capacity, from the shipbuilder's light line, that is the flota-

tion line as the vessel leaves the builder's hands, to the deep load summer draught line allowed by Lloyds, of 4,180 tons, from this must be deducted sea stores of all kinds, dunnage, and coal for the voyage, this will reduce the cargo capacity, for dead weight freight, to about 3,500 tons. This statement is made in case it might be asked why there should be such a difference between the dimensions of a vessel to carry 6,000 tons and those of one to carry 4,000 tons, and for no other reason.

If our merchants do not at present want the "County Line" I trust they will help the Johnson-Locke Company. My purpose was to present to the merchants an outline plan of a vessel that would make regular and reasonably fast trips, with every appliance for the rapid handling of general freight, in fact a fast freight ship of the most modern type.

Ten years ago I advocated first-class freight steamships for this business, and this is the original plan made at that time, the only change I have made is to increase the indicated horse power by 500, and adding 1 foot 6 inches to the beam. At that time this plan was considered too far ahead of existing types of freight steamships, the transportation of freight on the Atlantic was then, for the most part, done by vessels carrying passengers, or by old passenger vessels that had become unfit for the higher class of work.

The Monarch Line has built some special freight steamships carrying about 4,000 tons; the cost of transportation was reduced, the great lines had to build special fast freight ships to enable them to keep in the business, so that now they have grown to about the dimensions I proposed for the San Francisco, New York and Liverpool trade.

Let me instance the development of the fast freight ships of the Oceanic Steam Navigation Co.'s ships, that is the White Star Line. I take this line because of their intimate connection with one of the most progressive shipbuilding firms in the world, Harlan & Wolff, of Belfast. In 1882 this Company felt the necessity of providing special freight vessels, and Harlan & Wolff were ordered to produce two vessels to carry 5,000 tons dead weight cargo, besides fuel, stores, etc. The result was the *Doric* and *Ionic*, both of which went into service in 1883, and are still in the service, and average nine round trips a year. The dimensions of these vessels are, length 440 feet, beam 44 feet, depth 31 feet 6 inches.

These vessels have the ordinary compound engines, and on that account burn more fuel than those of a later date. In 1887, Harlan & Wolff built another special freight vessel for the White Star Line—the

Cufic. In this vessel the only change in the dimensions made was adding one foot to the beam, making it 45 feet instead of 44. The engines, however, are triple expansion. This vessel carries 5,600 tons dead weight freight, less coal being required than in the older boats. In 1890, they built another boat for the same company. This vessel, the *Nomadic*, which commenced running about the middle of 1891, makes her trips in ten days; carries 6,800 tons dead weight freight, and is of the following dimensions: Length, 461 feet; beam, 49 feet; depth, 32 feet. This vessel makes 11½ knots, loaded, on 33 tons of coal per day. Compare the dimensions of this vessel with those of the *County of Contra Costa*, or those of the ship proposed ten years ago, and it will be observed that they are almost identical, so that what was then considered too far in advance, is now only abreast of the best practice.

In some communications to me, the rig of the proposed vessel has been objected to as being too heavy. Rapid and economical handling of freight is of great importance in a vessel of this character, and to be rapid it must be handled from all compartments at once. We have eight independent holds, and five masts are necessary to provide cargo booms for each hatch. To be economical, it must be handled by the ship's own tackle, and I have provided for its being so handled.

In regard to the sail power, the sail area relative to the flotation area of the vessel is about the same as that of the *City of Pekin*. When preparing the earlier plan for this vessel, I had some talk, in regard to sail power, with the late Captain Berry, then commanding the *City of Pekin*, and inquired how it was that he managed to make so good time with such a small developed horse power. He said that he never let any wind slip past his ship without getting some horse power out of it. Mr. Forsythe, who sailed as chief engineer with Captain Berry, will be able to tell us how the sails were used. It was in the hope that the class of captains to which Berry belonged were still on deck that the *County of Contra Costa* is shown square rigged on four masts.

The question has been asked: Why have a spar-decked vessel which is not usual in freight steamships, and adds to the register tonnage, and why carry all bulkheads to the spar deck?

In providing a spar deck, the first object was to provide ample space for a large amount of light freight, such a dried fruits, wool, etc., which must be kept dry, and must also be ventilated. It also gives the ship a good free board, enabling work to be done on deck

with some degree of comfort. Carrying the bulkheads intact to the spar deck, enables different classes of light freight to be kept separate. One kind might taint another if not separated by air-tight bulkheads. In case of fire, water can be used on one part of the cargo without any damage to another. Compartments can also be prepared for cold storage, if necessary. Shippers can secure independent compartments on certain decks for their own freight, and have it subject to a certain treatment on the voyage. The advantages of this arrangement will at once occur to shippers whose goods must not be subjected to the possibility of taint from other materials while on ship board.

The possibility of making the voyage in the time stated, and on the fuel provided, has been questioned. One evening newspaper, in an article published on the 26th of last month, takes, for an example, the case of the *Alameda*, which made the voyage from New York, without any stoppage, in 59 days, and this vessel averaged 13 knots per hour, and asks, triumphantly, how the *County of Contra Costa* is going to cover the same distance in 50 days, making 11 knots? Now, this party who demolishes my figures so cleverly, evidently knows it all by heart without any figuring; he deals with known facts, and you know that there is only one thing more misleading than figures, and that is facts. Now, here are two facts stated: 59 days and 13 knots, that is 312 knots per day, and 59 days at that rate would be 18,408 knots, that makes some trouble about these facts. If we take the fact of 59 days and the true distance, then the average speed was $9\frac{2}{10}$ knots per hour; if we take the other fact of 13 knots, then the time was 41 days and 16 hours. This writer, having disposed of my figures with his facts and, as he says, having shown me wrong in one item, concludes I must be wrong in all. We will not dismiss him in that way, but will refer to him again as occasion requires.

As an instance of what may be expected on a long voyage like this, with a ship specially designed for the purpose, I will give the first voyage out of the new freight steamship *Tekoa*, just built by Gray, of West Hartlepool, for the New Zealand Shipping Company, to run between London and Auckland. (Imagine little Auckland having ships that San Francisco can't afford). This vessel is 469 feet long, 49 feet 3 inches beam, and 33 feet deep; engines triple expansion, 27″ and 43″ and 72″×45″ stroke. Compare this ship and engines with the *County of Contra Costa*, and see how closely they approximate to each other.

This vessel left London a little over three months ago with 6,250 tons of dead weight freight, and 1,400 tons of coal in the bunkers, steamed 12,059 knots without any stop whatever in $50\frac{9}{10}$ days; average speed $9\frac{87}{100}$ knots per hour; coal consumed $1,081\frac{3}{10}$ tons, or $21\frac{1}{4}$ tons per day. This is a splendid result in fuel, considerably better than I expected to do in the *County of Contra Costa*, and it shows that 50 days is not only a possible time for the voyage from here to New York or Liverpool, but for a modern ship it can be done at a very economical expenditure of fuel.

Having considered the first question, that relating to the ships themselves, we will now consider the second question, that of operating them. Can these vessels be operated with any degree of certainty on the total expense allowed in my estimate? None of the communications to me have questioned the expense, but the article already referred to, in an evening newspaper, appears to have some weight in certain quarters, and therefore requires to be answered.

The first question asked is "why has no allowance been made for insurance of hull?" The writer of this newspaper article has not dealt with my pamphlet as it is, but has it mixed up with another proposition on page 11, suggesting the method of ownership of the proposed vessel. I provide that each owner can handle his own share as it suits him, can dispose of it as he pleases, can insure it or carry the risk as he sees fit, and on page 15 in stating that the amount divided would equal about 24 per cent. per annum, it is also given about 6 per cent. less to owners who insure. The question of time to make a voyage has already been noticed.

The next question raised is the time allowed for loading and unloading. The reference that this writer makes to time in way ports need not be considered, as no mention is made of way ports in the pamphlet. My proposition was for a direct line, but should there be business for way ports the time required at such ports would be added to the 50 days at sea and deducted from the 50 days in ports.

Our friend figures that on a round voyage, carrying 6,000 tons each way, 18,000 tons must be handled, and I forgot that fact for I had calculated on having to handle 24,000 tons. We will not discuss this question with the stevedores at present, but will refer to the time taken in port by similar vessels, referring again to the trans-Atlantic new freight steamer the *Nomadic*. I find that this vessel makes a complete round trip in 40 days; 22 days at sea and 9 days in port at each end, and carries 6,800 tons cargo. Here is 27,200 tons

of freight handled in 18 days, and the "County Line" people cannot handle 24,000 tons in 50 days.

If this writer had cared to inquire around our own docks he could have obtained some facts on handling freight not quite in accord with his conclusions. The Pacific Mail Line ships from this port to China, are near the size of vessel we propose, and being also passenger vessels, are very poorly adapted for handling freight, yet if these vessels are on schedule time they have but 15 days in port to discharge and load coal, and do any repairs that may be required, and when occasion requires, as in the last trip of the *City of Pekin*, on account of going into quarantine, it can be done in half the time. The Occidental and Oriental chartered vessels, belonging to the White Star Line, in the same trade with this port and China, if they are on time, have 16 days in port, and as to going like clock work (as this writer seems to think outside of the possibilities), the White Star steamers, running from here to China, do run like clockwork, none of them having missed a sailing day for 4 years.

The next question raised is that of port charges. Nothing is allowed, it is said, for loading and discharging. The amount to be paid for labor under this head was included partly under the head of port charges and partly under the head of wages. It will be observed that the full crew is maintained during the whole time in port, and provision account is also for the full force the full time. The cargo would be handled as it is on all such vessels, by the ship's own appliances, under charge of the ship's crew, outside help being engaged for breaking out and stowing cargo. If the crew leave the vessel more help would be required outside, but the wages bill on the ship would be less, and less provisions would be consumed; $1,400 was the amount allowed for outside help in handling freight in port. The New York freight steamers of the highest class allow 8 cents per ton for this work. I have allowed 12 cents, which would allow 16 cents at San Francisco and 8 cents at New York. Regarding the wharfage at San Francisco, this writer places it at $1,749.75. Now the per diem dockage of a vessel in this harbor is $4.00 for the first 200 tons, and ¾ of a cent for each additional *net* register ton. Vessels lying idle, or taking in cargo, are subject to only half rates. Our vessel would be 8 days subject to full rates, and 17 days subject to half rates, that is if the line could not lease wharf accommodation.

The net register tonnage, according to the plans, would be about 3,800. That would make the full rate dockage $31.00 per day; 8

days equals $248.00; 17 days, at half rate, equals $263.50, or a total dockage bill of $511.50; this leaves $1,088.50 for pilotage, the service of a tug, if necessary, and such things as would not be classed as incidentals. The dry docking of the vessel, which I had provided for at the outward end of the voyage as a mere matter of modesty, is also questioned, the writer stating that I had provided $5,200 for port charges and dry docking at Liverpool. The actual figures given in my estimate are $5,800.00. The intention was to use white zinc and tallow for the bottom. Material and labor for this work would cost in Liverpool $550.00, in San Francisco, $850.00. The dock dues for two days in Liverpool would be $1,392.00. Dock dues for two days, at present rates in San Francisco, would be $2,320.00. $2,800.00 having been allowed for docking and painting in Liverpool, deduct the cost of labor and material in San Francisco, leaves $1,950.00 for dock dues, should the vessel be docked here. Ten ships, docked once in five months each, would be 24 dockages, making $46,800.00 a year for dock dues.

The California dry dock people, I think, would be willing to contract now for the use of their dock at such rates. If an Atlantic freight steamship, say the *Nomadic*, incurred port charges equal to what I have allowed for the *County of Contra Costra*, it would equal $1.77 per ton of freight she carried, and this comes very near to equaling the rate at which she carries freight. In fact, I had made my estimate high to be perfectly safe.

There are other points brought up in the article referred to, which is really a very clever presentation of the objector's side of the case. He ingeniously works in the shippers' insurance on the goods shipped as part of the operating expenses of the ship. If his argument were for a higher rate of freight by rail than by sea, his point would be well taken, except for freight that has to cross the Atlantic before going on the rail, as the railway companies insure the freight while in their hands—the steamship owner does not.

Next the revenue of the County Line is questioned. According to this writer the competition is to be, not with rail freight but with the sailing vessel, and yet he advocates a competing railroad to relieve the distress of our merchants. Is this new railroad also to compete with the sailing ships? He says "dry goods merchants must have their goods from Europe in as quick time as ocean greyhounds and fast railway freight trains can bring them hither." Again he says "when the steamer arrives here they would have to wait a week or two until their goods were brought up out of the

hold." Let us investigate this poetical statement a little. How is it that this merchant who is in such a hurry for his goods, gets them out of the same kind of a ship's hold in New York, without any loss of time, while the same operation takes one or two weeks here? More than that, he generally ships from New York by the Sunset Route, so the merchant who is in such a hurry, according to this writer, must wait two weeks to get his goods out of the ship's hold in New York, ship them into another vessel, which, according to this authority, must be ten days loading, for they take 4,000 tons, then another ten days again to get them out of the ship at New Orleans before they get on to his railway.

Again, he says: "The merchants cannot afford to run the risk of almost certain delay in the voyage by the Straits of Magellan. They, with the fine leather merchants, with carpet dealers, even the hardware men, in many kinds of hardware, cannot afford to run the risk of damage by sea. For however closely a vessel may be constructed, the goods in the hold are sure to be damaged to a certain extent by leakage." This is a sad commentary on the ability of our ship builders to construct ships that will keep cargoes dry, yet these very dry goods merchants, leather merchants, carpet merchants, and even the hardware men, are just the men we want to carry freight for at $10.00 per ton, and they are not so much afraid of salt water either, for they ship at Havre and Liverpool on fine freight steamships like the "County Line" across the stormy North Atlantic, where their decks are often covered by seas all the way across, and ship them again on another steamship to New Orleans, and all without damage by water, and at from four to six times the cost at which it can be done by the "County Line."

Our ships might have to carry some classes of freight at five to six dollars per ton, but the freight that is now crushed by railroad rates, and that must be moved quicker than the sailing ship can do it, is just the freight that can afford to pay good steamship rates. As it must take the same time to get goods into or out of any two ships of the same character, and each fitted with the same facilities for handling freight, the question will present itself to the merchant something like this: To import goods from Europe by the present arrangements the time will be: 3 days to load, 11 days to cross the Atlantic in one of the first-class freight steamships; 4 days to discharge in New York; 2 days to load on Sunset steamer; 18 days from New York to San Francisco, and 1 day for delivery; total, 39 days—as the shortest possible time. To ship by the County Line

would be: 3 days to load; 50 days to San Francisco; 4 days to deliver; total, 57 days. Now, if the difference between 130 days by sail and 57 days by steamship is not worth any difference in freight rate, why should the difference between 130 days by sail, and 39 days of steamship and rail be worth ten times the rate of freight?

A correspondent writes me that while the steamship line would be a present relief to the commerce of San Francisco, yet the salvation of the San Francisco merchant can only come with the completion of a canal which would cut the steamship time down to 27 days. While my correspondent is right, we must remember that if the means were already secured to construct the canal, it would be ten years before one of our steamships could pass through. We have already seen that the ships we propose are similar to the best types of freight steamships, for shorter routes, so that when the time comes when a steamship can go through the canal, the "County Line" will be as suitable for the business as anything that floats.

I have not exhausted this subject by any means, nor have I touched on all points that have been brought out in connection with the discussion that has been going on in the newspapers, but I have said enough to bring this subject properly before the Society, and draw from those present, who are interested, such an expression of opinion as will clear up many points on which the public are not very well informed. I trust the discussion will be without reserve, as I understand the Society makes this an open night, non-members having a right to take part.

After reading the paper, Mr. Dickie added the following:

"Some time ago in talking with a ship captain about the different ports for sailing vessels, he said that San Francisco was about the only port that was left unravished by steamships. I asked 'what is the reason San Francisco has been left out?' He replied 'I don't know, unless it be that the shippers and the merchants of San Francisco have not found out yet that ships are propelled by steam. If they ever find out that ships are propelled by steam our business is gone.'" Mr. Dickie added he would be glad to receive questions and criticisms from both members and non-members.

DISCUSSION.

MR. MANSON.—"Mr. President, I think we owe a good deal to Mr. Dickie for bringing up this question at this particular time. The last time this Society met in this hall one of the naval officers of the United States Navy pointed out to the Society, and to this

community, the advantages to be derived from the construction of the Nicaragua Canal. Mr. Dickie touched on that, and showed the importance of San Francisco owning and operating, for San Francisco, her own ships. Ninety per cent. of the vessels that come to this port are not run for San Francisco, but simply to get as much out of our merchants as they can, just as the railroads do. We might as well understand the fact that they are not going to reduce rates until the merchants themselves get together and force them to do so. I would like to see a railroad running out of Chicago attempt to discriminate against the Chicago merchants; Chicago would have the railroad in the hands of a receiver in no time. The Board of Trade and other bodies of citizens would not allow that railroad to exist.

Now the Suez Canal, the Panama Canal, or the Nicaragua Canal, are not going to do us any good unless we own the steamships that run to, and in the interest of San Francisco. We are here on the borders of an ocean with 80,000,000 of square miles of water, and the wealth around that ocean is untold, and we own no great line of steamers, not even a line of sailing vessels. We sit down here and prate about the benefits that a canal, constructed by somebody else, will give us through the ships of somebody else. I think Mr. Dickie has struck the nail as squarely on the head as he possibly can do, in calling attention to the fact that we want to own and operate our own steamships for our own interests."

CAPT. W. L. MERRY.—" Mr. President and Gentlemen: I did not come here to talk, but to listen. The subject is a very old one to me. I spent sixteen years of my life at sea, and for seven years I was in command of ocean steamers. They had side wheels, long stroke, and consequntly now are behind the age.

In the first place there is not the slightest doubt that steam carriage by sea is as cheap as any transportation known to commerce, and especially for short voyages the steamship can compete with sailing vessels. The steamers we are now commencing to build which run at a low rate of speed—about ten knots an hour, for the carrying trade, can compete with sailing vessels on long voyages.

As San Francisco is a sea port her development must come from the use of her sea board. It cannot be accomplished through the railways. They can approach only from one side, it is not a center with railroads reaching out in all directions.

An ordinary ship takes 3,000 tons of freight, and that will load 30 trains of 10 cars each.

Now this question of Mr. Dickie's is an interesting one, because it is a solution of the great need of San Francisco at the present time. Of course it will obtain its best results with a shorter trip through the canal. That will, no doubt, be the ultimate solution. At present, however, the route is the worst one of the world, because it is the longest route; and, as I have said before, the longer the route the greater the disadvantage the steamship has to compete with. There is no voyage in the world, that I know of, that is harder on the steamship than from New York around Cape Horn to San Francisco, on account of its length, crossing the equator twice and passing through the heat of the tropics.

The pamphlet published by Mr. Dickie I have read with great interest. I differ from him in some respects, but in the main I agree with him. I, however, suggested to him that, according to my American ideas, I was in favor of a little more beam, and suggested twin screws, so that in case one should break down the other could keep the ship going.

I have another objection, and that is the ship's name. A ship was building up in Maine somewhere, and the Captain visited Boston to report to the owner how it was getting along, he reported that it was nearly ready to launch and asked that they select a name. The owners told him they wanted a short name, one that was easily spelled, pronounced and written, and any name that would meet these requirements would be satisfactory, and requested him to select one. When the captain came to Boston again he was asked what name he had given to the ship. He replied, 'I thought of all your requirements, and after thinking the matter all over I called it the *Ox*, you can't find anything better than that.' But this is not a part of the argument. I should select shorter names simply to save time. The ships are long enough without having such long names.

The question is one of great interest to San Francisco. But if you go to the merchant today and say to him, 'here is a steamer that will land your freight with reasonable certainty in 60 days, and the sailing ship will land your freight with less certainty in 130 days, how much more will you pay for the reduction in time and an increased certainty in delivery?' do you know that man will say very little. I have been astonished to see how little they would say. They appear to think that the saving of time and the additional certainty of delivery is a matter that does not incur a great deal of extra expense; consequently they do not give the encouragement

necessary for men to invest in anything of the sort. They are apparently oblivious to the fact that the saving in time and the greater certainty of delivery is a great factor.

From all that I can gather, the question at best is a very close one. I think a steamship line from here to New York, with modern steamships, could be made to pay 8 per cent. per annum on the cost of vessels and operating expenses.

According to the laws of this State vessels registered here are taxed their full value. New York has no laws of this kind, and in Massachusetts if the ship earns nothing she pays nothing. Here a ship worth $1,000,000 is taxed $27,500 a year. If you had them here you would register them in New York and Boston to avoid that taxation. The policy of this country has been to damn the shipping industry and foster railroads. When I was a boy we were a maritime nation. England is a maritime nation, but without her ships she would be nowhere. We are a great country without ships, consequently we do not depend upon ships as I think we ought to for our own benefit and our own advantage. But San Francisco is not so much to blame; generally money can be better employed than in shipping, it can find better investment. When I was a boy everything was done to build up American commerce. We had all kinds of legislation for the encouragement of shipping. We have stopped encouraging shipping in any shape, and then we ask why we have no ships. On the contrary we legislate for railroads, and give them enormous land grants. Until these conditions are changed we will never have successful shipping.

I will be delighted to have San Francisco take up this question, but until the voyage is shortened by a canal there can be no large fortunes made in this direction, in my opinion. I think by economical management there might be a return of 6 or 8 per cent. In the main I am in sympathy with the ideas of the speaker."

CAPT. GOODALL.—"I did not come here to address the Technical Society; I believe rather in a practical operation, and the technicalities I am disposed to omit. Not being sufficiently acquainted with these I leave them to the wise engineers, who consider these matters at their leisure, and make a very fine effort when they tell us about them.

I want to lay Mr. Dickie's plan on the shelf, so far as the Liverpool proposition is concerned. If it is so practical to run steamers, such as he has planned, to Liverpool, there would be no difficulty in the way of English people running their tramps here at

once. They have acres and acres of vessels lying still, waiting for something to do. (They had when I was last in Liverpool, and I think they have at the present time.) They have shops and shops, boiler shops and machine shops, and shipyards. They want business of this kind, they want ships to build, and they will build them for about half what Mr. Dickie proposes to charge for building the same ship. When they get them built they will run them for about 60 per cent. of what they can be run under the American flag, and owned in San Francisco. An English ship with an English crew, and English living, black bread, barley soup, and mahogany for meat differs from an American ship with condensed milk, fresh butter, and mince pie. It soon amounts to a difference of 60 and 100 per cent. Therefore I say it is impossible that Mr. Dickie's ships can run to Liverpool and pay.

As to New York, that is a different proposition, but the question is whether the railroads would allow it to be done. The railroads have five tracks now running between this Coast and the East in some manner or other; therefore they have found it necessary to raise the freight. With more roads, and an increased number of officers and offices, they must have increased operating expenses; hence a higher rate of freight. They are not going to take their tracks up. They are insane on what they call the 'long haul.' They would rather haul a ton a hundred miles than twenty miles, just for the sake of having a 'long haul,' if they can get the same price for it. Mr. Huntington, in his letter in the *North American Review*, says the law regarding this matter of the 'long haul,' is unjust; that the railroads should be allowed to run the steamships off because they can go somewhere else to make a living when the railroads cannot. A railroad has to confine its business to its particular track. That is Mr. Huntington's theory, because he is a railroad man; my theory is that this should not be allowed, because I am a steamboat man. As soon as steamships reduce freights they will make a strong fight. They will do the best they can under the circumstances. Railroads are run to make money, exactly as you run your mercantile operations, the Union Iron Works, and everybody else carries on his business to make money. When the railroad has run your steamships off then the people will have to pay higher rates to make up the loss of the railroad during the competition.

One more proposition: I don't think Mr. Dickie can run the ship as cheap as he imagines. He knows how to *build* the ships, and

build them very cheaply ; but I have had some experience in *running* his ships. He estimates, for engines of 2,200 horse power, a consumption of 1½ pounds of coal per hour per horse power. Now we had one of the finest ships that Mr. Dickie ever built, and it takes 2½ pounds of coal to the horse power per hour. We also had an engine made by him put into the steamer *George W. Elder*, which is somewhat smaller than those he proposes to build. She made a trip to Callao when there was trouble there, and she made 8¾ knots per hour, and burned 15¼ tons of coal in 24 hours. They were modern engines, which Mr. Dickie built or designed himself —a splendid piece of work ; as fine as can be made anywhere. I don't think his "County Line" could have any better. I don't see how he is to run these larger vessels at the rate of 10 or 11 knots an hour and carry 6,000 tons of cargo on his allowance of coal.

Mr. Dickie is a little behind in the number of miles from here to New York. We had three ships make the trip that averaged 13,600 miles coming through the Straits of Magellan. According to Mr. Dickie's figuring he would be about two days away from New York when he thinks he is there.

There is no doubt that Mr. Dickie is all right about the building ; he has money enough for that—$680,000. I own a little in the Union Iron Works, and I hope he will get one to build at that price, for then I would get my share of the profits.

Somebody else has written an article in the papers giving the cost and profits of smaller vessels than Mr. Dickie proposes. This writer puts down $220,000 as the cost of building a steamship carrying 4,000 tons, and running that ship on something like 14 tons of coal a day, and getting 10 knots an hour. It seems to me that is a hair-brained proposition, too. I think there is a mistake about this business, and I shall have to take issue with Mr. Dickie in the matter of running expenses."

W. L. MERRY.—"There are one or two points that I cannot agree upon with Captain Goodall. In small steamers there is always a disadvantage in carrying freight as compared with larger ones.

As to the distance between here and New York, I have investigated that very thoroughly, it averaged through the Straits of Magellan, 13,560 or 13,580 miles. But these are nautical, not statute miles, which makes quite an essential difference.

The criticisms he has made by comparisons with the *George W. Elder* are hardly fair ; between this and the ship Mr. Dickie proposes to build there is an enormous difference in the type and character

of freight it will carry, and in the tonnage. I have no doubt it would show a greater capacity and less use of coal. I don't think it is a fair comparison to make between these two classes of vessels."

CAPT. GOODALL.—"I made a reference to a brand new ship planned and built from bottom to top by Mr. Dickie, and what he does not know about building ships and engines no one knows. The little ship called the *Pomona* developed about 1,000 horse power, and burns 2½ pounds of coal to each. She makes about 13 knots an hour."

MR. DICKIE—"The main point made in this discussion, and it is a very important one, has been made by my venerable friend the Captain, in regard to the consumption of coal. Now I stated in my pamphlet that the fuel was first-class steam coal, that the estimate was based on Cardiff coal, and the price allowed that paid for Cardiff coal at both ends, delivered to the ship. Now other vessels of the same size as this ship are doing this work, and doing it every day on the fuel that I have proposed. The horse power requisite for the speed is 2,200 for a vessel carrying 6,000 tons of freight. Captain Goodall's vessel carrying 1,200 tons of freight requires 1,000 horse power, although a development of 700 horse power would give the same speed that I propose.

I am referring now to the *Pomona*, and the Captain's statement of the consumption of fuel on that vessel needs some explanation, otherwise this statement might be compared with the consumption on other vessels, and our reputation suffer in consequence. Having seen the Captain's computation of fuel burned, I am in a position to explain how he arrives at the result of 2½ pounds of coal burned per horse power developed.

The *Pomona*, running in the Eureka trade, averages 43 hours running time, that is from the time the captain gives the go ahead bell to the time he slows down at the other end the average time has been 21½ hours. Now, so much coal is placed on board for the round voyage for all purposes, this amount the Captain divides by 43 hours, and then by the horse power shown by the cards taken during the trip. Before he made his computation against the consumption per horse power of the engines, he should have deducted the fuel required to get up steam in San Francisco, the amount used in a donkey boiler, taking in freight, the amount used in the kitchen on the voyage up, the amount used in Eureka hoisting out and in freight, and getting up steam for the down trip, and the amount used in the kitchen on the way down. With these deductions

he will find the consumption of even the poor quality he uses not more than 1¾ pounds per horse power per hour on the *Pomona;* the percentage used in ports where the voyage is less than one day is very great, and this case will not compare with that of a 50-day voyage. The power does not increase as the displacement, but with the skin resistance of the vessel—the wetted surface, and some other factors that enter into it.

Now I have stated in figures tonight the facts. Here are vessels crossing the Atlantic carrying the amount of freight I propose for these vessels, and they burn the amount of fuel I have allowed. Two of the larger vessels on the Atlantic, of the White Star Line, have developed a horse power for less than 1½ pounds of coal. It depends upon the kind of coal that is burned. Capt. Goodall knows that the kind of coal used in his vessels is not the same as would be used for an economical long ocean voyage. These vessels must have steam coal, Cardiff coal. With that kind of coal and the proper means for burning it, the consumption will be, in fact, less than what I have stated.

Regarding the distance the vessel would have to run, I was in error. I had assumed 13,060 nautical miles as the distance. That would make a difference of three eighths of a knot of speed in the vessel to make the time I have stated. But the amount of coal provided was sufficient for six days more voyage than the time given for the ship. The statement of power, and the statement of fuel consumed upon a freight steamer that has just made her first trip to Auckland, I know to be correct. Her consumption of coal was slightly under 1½ pounds in the development of horse power up to 1,700.

As to the certainty of long voyages, the Orient Steamship Co., whose ships run about the same distance, are very regular in their sailing days. The voyage to the Australian Colonies from England is nearly as long as the voyage around our continent by the Straits, but not as severe. The modern steamships can be made just as reliable as the railroad train. They are subject to accidents, but these accidents are not of so frequent occurrence as one would suppose, that is, in vessels that have been built expressly for the business.

Reference has been made to a vessel that came in here, for a few days, that made an exceedingly long trip around the Horn. That vessel is not fit for any kind of business. If we propose to carry freight from San Francisco to Europe or New York, or from these ports, in such vessels, we will meet with failure, and we can't do

otherwise. The idea of cheap ships ever being employed in this traffic must be abandoned, for it will never succeed.

It has been stated here tonight that ships could be built in England for half the price I have stated. I happen to know the prices of several ships on the White Star Line. One of the steamers cost $584,000, and she is 20 feet shorter than the ship I propose. It has the same outlines and engines exactly. That vessel is employed between Liverpool and New York, and the average amount paid for freight carried in that vessel is less than $2.50.

Captain Goodall says these ships would be run out of the business by the railroads, who would reduce the freight. Well, this is one way of getting even with the railroads, if the railroads reduce the freights you have only to keep the steamships going to keep freights reduced.

There is a deeper question than that. No company can run at a loss except for a short time, or for a certain purpose; they cannot do it forever; the railroads must earn enough to pay running expenses. Now it takes the same amount of fuel to carry one ton a mile on the railroads in this country as it does to carry the same amount 20 miles on an ocean steamship of the latest make. Such are the statistics in England, and they have been compiled very carefully. Now it is simply a question of endurance. I hardly think it is possible that they can come under a cent a pound for freight and pay expenses. When the Sunset route was opened, the railroad people were going to carry the wheat that way to New Orleans, and ship from New Orleans to England at $10 a ton, and that is the freight I proposed for these vessels. The question is simply this, is $10 a ton reasonable for carrying goods from New York to San Francisco, or from England to San Francisco on 50 or 55 days' time? If that is a reasonable freight then the steamships can do it, and do it profitably. That is really the only question. The railroads cannot do it profitably at that price. If the fact of a few steamships would reduce the charges for freight on the railroads for all trans-continental freight, it would pay to keep them running even if they carried nothing. They could run opposition to Captain Goodall now and then, to keep up the status of the concern.

The cost of building ships and the cost of running them is a matter that can be brought down to figures, and the statement that a vessel of the size I propose can be built in England for $200,000, or $300,000, has no foundation in fact. We are not talking of tramp

steamers, but of first-class freight steamships, and they do not compare with each other at all.

Captain Merry raises a question which I think the most important raised tonight. That we have to pay a large amount of the earnings of our steamships for taxes. Now this is a matter that lies entirely with the people themselves; they make the taxes; and if it is a good thing for San Francisco to have steamships, they can legislate to remove the tax on steamships.

CAPT. MERRY.—"I will state in that connection that the new Constitution stands in the way, for it says all property shall be taxed. It is a question of getting a new Constitution, and that is a very hard matter to do. I would be pleased to see it. It is now simply a matter of registering somewhere else. The Pacific Mail steamships are all registered in New York."

MR. DICKIE.—"I may state about the cost of ships for the U. S. Navy, now building here, that if the material for them were brought on steamships for $10 a ton from where it is manufactured, it would reduce the price of one of these vessels in San Francisco $46,000. That is the difference between carrying this freight by steamship and by rail. We are building a warship of 10,000 tons displacement for the U. S. Government; if the material that comes from the East for that vessel could be brought by sea in the time that I have stated, and at the rate of freight I have stated, on that one ship it would make a saving of $97,000. Now, there is money in this matter of carrying freight. It would pay to run a steamship to get the railroad people down to the same rates under these circumstances."

W. L. MERRY.—"What do you consider the difference in cost in the building a first-class ship in Philadelphia compared with the cost of the same ship built at Liverpool. I see that Cramp says in an article in the *North American Review* that he can build as cheaply as in England."

MR. DICKIE.—"I understand him to mean that a ship of a special class he can build as cheaply as they can in England. They can build an English ship cheaper than we can. For instance, Elder & Co. can build an Elder ship cheaper than we. To build *the same* vessel cannot be done as cheaply here as there. The material and the labor cost about twice as much; the main difference is, the ship builder gets a larger profit in England than he gets here. There are ship builders and ship builders in England, and it is very difficult to predict what would be the price of a vessel. The White Star people have been offered between $600,000 and $700,000

for a vessel that has been running over 22 years, and it is almost as much as the vessel cost, and yet it could not be bought.

Vessels for special purposes are not cheaply built in England; but vessels that are standard ships and built by the dozen by everybody, and where no reputation is involved in the building, and when they are lost no one asks who built them — such vessels are built very cheaply."

CAPT. GOODALL.—"What do you think of a ship constructed to carry both freight and passengers, and to stop at Callao, Valparaiso, and Rio Janeiro?"

MR. DICKIE.—"A ship carrying passengers as well as freight, and stopping at way ports, is a subject that is not in our programme tonight. That is a matter of steamship management more than steamship building. It is a question I have not sufficient knowledge of to give information that would be worth anything."

CAPT. GOODALL.—"In my opinion, that is the practical way to do the business. A large trade could be developed between these way ports at good prices, and if the railway people compete on the long route, the local business can keep the ships running."

CAPT. MERRY.—"I made several trips to Australia in sailing ships chartered by British merchants, and at that time that work was done by large clipper ships. That was along about 1859 or 1860. This business has now entirely left the sailing ships, and there are very few in that trade, the steamships have taken it away. That is more analogous to our ocean route than any other. The voyage is long, and a portion of it is tempestuous; but notwithstanding that fact the lines of steamers between Australia and England have absolutely run those sailing vessels off, and many are now hunting trade from San Francisco.

Another point I wish to mention is this: Mr. Huntington is a very astute man; he is probably one of the best financiers in railroading and one of the shrewdest operators that this country has produced. That man, when he saw he had to make a fight on overland traffic, notwithstanding he owned a railway from Newport to New Orleans, practically had his connection from Newport to New York, he bought out the Morgan line of steamships between New York and New Orleans, for the express purpose of making that fight and beating the overland railroads; and notwithstanding that route is attended with several difficulties, he has been able thereby to dictate the policy of the overland companies crossing the continent. When you come down to the basic fact, water transportation will

always beat railways when time alone is not requisite. It is Nature's highway—it is God's highway; it requires no tracks; it is free to everybody, and when we consider how much greater the operating expenses of a railway are than running ships, we can see how difficult it will be for railways to compete. Water transportation will always beat the railways, provided there is an opportunity to put the ships on, and getting freight for them. I think that is a demonstrated fact.

I tell you, gentlemen, this is really the solution of the position of this port. It will never be a railway center, from the fact that we are at the end of a long haul, and can have railways only on one side of us. As a seaport we have great advantages at our command. Until this is made a seaport in the full acceptation of the term, San Francisco will never be what her locality should entitle her to be in future."

DISCUSSION OF TOPICAL QUESTIONS.

[Held Dec. 4th, 1891. From stenographic report.]

The following question was submitted:

How can we account for the fact that machine work in San Francisco is, with few exceptions, not made to standard sizes?

MR. RICHARDS.—"I am qualified in one way to say something upon this subject, that of always having felt a great interest in it, and have never been able to discover a single reason why work in San Francisco should be made to no standard whatever, of any kind. As to giving you any light upon the subject, I have something to do with standard measures, but remarks upon that subject would hardly be speaking to the question.

To make use of a national standard would, in some parts of the world, increase the value of machinery ten per cent. In Sweden, for example, machinery not made to standard sizes would be reduced ten per cent. in value. I think the same is true in South and Central America, but am not so certain about it there. The commercial phase of this question is of particular importance. As to the mechanical part, there are none better able to discuss it than the Technical Society; not only a few, but a great number of its members. Perhaps Mr. Dickie will favor us with a statement of the facts as they exist."

MR. DICKIE.—"There are some things in regard to measures that are not standard that can be explained. For instance, an inch board is seven eighths of an inch thick, and a two-inch board is one and three-fourth inches thick. The reason of this seems to be that the person who cuts up the timber expects to get so much out of it, and adjusts the sizes accordingly.

In regard to iron work the same rule prevails. Shafting has been made, as a rule in San Francisco, from merchant bars, and each shop, I believe, has a different gauge for shafting, and these are in a large degree dependent upon the opinions of the foreman of the shop.

Sometimes the standard has to be changed for shafting. I remember, eighteen years ago, of a very large shipment of bars for shafting from England to San Francisco, none of them would turn up to the gauges, and the gauges had to be made to suit the shafts. So it has gone on until we find that each shop has a sort of independent practice which prevails in these matters.

Why it continues now is a mystery; there is no necessity for it whatever. It is a source of infinite trouble, annoyance and confusion. Suppose that a Mexican firm sends here for a certain size of shafts, and they are sent there, and they are not to standard size, there is trouble about it. I think our company has a good many tons of shafting in Mexico that has never been paid for, because not of the size ordered.

If the manufacturers would come together in a right spirit, they could regulate this matter. The great difficulty is that if one shop adopts a standard, the other shops adopt something else; they are enemies to each other, and they are apt to injure each other whenever they can. There is an opinion that if you send out machinery that nobody else can fit parts to, it will come back to the same shop for repairs.

Except for shafting, and round work generally, I believe there is a sort of gauge system. Unfortunately, each shop has its own. Until the proprietors get closer to each other, and will consult pleasantly about matters in general, there is no help for us. The only way by which this can be brought about is a better feeling among the manufacturers. A society like ours can not dictate to them, or influence them very much to make their work of the same size. Until San Francisco gets out of her provincial ways, in more things than one, we will have to continue as we have been doing. Everything is governed here by "certain powers," not amenable to technical influences.

Then again, as long as customers will accept a false shop gauge, and irregular dimensions without demurring, and as long as they are satisfied with machines that fulfill their purposes without any reference to standard gauges or sizes, that long the present system will go on. There are but two ways by which change can be brought about, either the customers must insist upon certain rules and regulations in regard to gauges, or else proprietors of establishments that manufacture machinery must get together, compare notes, and establish something in common that all will receive."

MR. BEHR.—"How do you manage in your own work?"

A.—"In shafting, for example, I get the actual size of the shaft. The Eastern manufacturers advertise their shafting, and give the actual size to which it is turned, and do not state that a shaft is three inches which is actually two and seven eighths."

Q.—"Do you figure the decimal foot and inch on your work?"

A.—"No. I use the English system of measures, inasmuch as we have not the metric system in use."

MR. VISCHER.—"To what extent does variation of sizes exist in the shops?"

A.—"A three-inch shaft would not fit a hole bored in another shop. It would depend upon what shop it came from; but roughly speaking, perhaps by as much as one sixteenth of an inch."

Q.—"What uniformity would you expect in work of a specific size, coming from the same shop? Does that also have to do with the matter? If a uniform system were adopted would not the work itself be better and more accurate?"

A.—"In most of the shops a uniform system is adopted, so far as shafting is concerned; that is, they adhere to their size. They have gauges for shafting, and a shaft is finished to these sizes. A pulley ordered from the same shop would fit."

Q.—"There is no economic reason why a uniform standard should not be adopted, is there? Would a gauge suitable to one shop be equally as suitable to another as far as the two are concerned?"

A.—"Yes. But arbitrary gauges should not be adopted; that is, standard sizes should always be adhered to. Nowhere is there any strict adherence to gauges where heavy machinery is involved; it would not be possible. For instance, in the reaming of a very long hole for bolts and connecting rod; bolts, say three and one half feet in length, it will often occur that one of these holes has to be reamed slightly larger than the others, and it is absolutely necessary

in order to bring things together. While the specifications might require that these things should be interchangeable, they are not strictly so made."

Q.—"At the same time the case you are stating now is not one of those which lies within the scope of your first remarks?"

A.—"No. In the matter of shafting, and round forms generally, as they are used, and turned work, there is no reason why standard gauges should not be used. There need be no arbitrary sizes; the standard gauge should be used as it is used for threads."

Q.—"To what extent is the more uniform practice carried out in the East?"

A.—"The gauge system prevails quite generally among manufacturers of machines. It is not used so much in regard to the manufacture of engines as of machines. In machines used in textile manufactures, for instance, a gauge system is absolutely necessary. If we on the Pacific Coast should manufacture such machinery gauges will be *forced* into the machine shops. I doubt whether the gauge system is carried out so perfectly in this country as in Europe. Mr. Richards knows better than I in regard to that. I know that in flax machinery a change wheel coming from almost any of the European works would take its place on any machine that had been made within the last fifty years, and fit perfectly. It is a great advantage to have it that way. I think the interchangeable system is nowhere carried out as it is in that branch. For spinning long flax there are gear wheels extending up to hundreds, and you may take a frame made in Leeds, and a frame made in Scotland, and, I think, also in France, and the same change wheel can be used on all of them.

The system of gear wheel making, too, is much more perfect there; not wheels that are cut, but those that are cast. I think one could give an order to Chambers for change wheels made by his machines to fit on a machine made by any other firm within a range of fifty years, and when received, it would fit in its place."

MR. RICHARDS.—"They do not make wheels in common foundries in England; that is a wheelmaker's special business."

MR. BEHR.—"Are all the calendered shafts made to the same gauge?"

A.—"They are made to a standard gauge, and very accurately."

Q.—"Do all manufacturers in England agree on the same standard?"

A.—"Yes. It is a national standard gauge."

MR. VISCHER.—"Are you able to tell us through what agency the uniformity that exists in Europe was brought about?"

MR. DICKIE.—"I think, perhaps, through the agency of half a dozen of the earlier mechanics about the beginning of this century who established gauges, and were persistent in maintaining and preserving them. Perhaps Whitworth has had more to do in establishing gauges for England than any other man. Before his time I think Clement was the first to work systematically with gauges."

Q.—"In the early days of engineering in the United States were there not American manufacturers who used their efforts in that direction—Sellers, for instance?"

A.—"That was at a later date. Although Sellers has always had gauges of his own. I don't think he has ever made any effort to make gauges that would be generally applicable to the work of the country."

Q.—"Was not his influence sufficient to make other manufacturers adopt his gauges?"

A,—"No. The Sellers' thread has not been adopted."

MR. RICHARDS.—"The American Standard Gauge Works, in Wilmington, have produced more gauges than any other firm in this country, but have not written about it so much. The gauges supplied exceed one hundred thousand."

MR. DICKIE.—"In regard to measuring by touch, has there been any other method used in shops as practical?"

MR. RICHARDS.—"I think measuring by sight is only a laboratory process. I am so prejudiced about it that I am almost afraid to make any remarks. I dislike the whole scheme of visual readings. A machine has been made by Sir Joseph Whitworth by which the one millionth part of an inch can be ascertained. A visual reading cannot do that. In my opinion it is impracticable, except as a laboratory method. I am speaking strongly so as to provoke discussion."

MR. SWAIN.—"Watch factories are using, almost exclusively, the sight gauges."

MR. DICKIE.—"There is one difficulty about measuring by any kind of visual reading. Most any workman or mechanic can understand touch—he can feel, but it is a different matter when it comes to perception by sight; there is always the liability of mistake by reading a scale wrong; it requires some education. But a lathe man who is accustomed to calipering, can feel with wonderful accuracy; some are exceedingly expert. Now, for instance, we put liners into

steam cylinders, and have to determine the fit required to put one in a cylinder under 80 tons pressure; we have our lathe men who can do this, and it will fit precisely in its place. That requires measurement that no sight reading that I can conceive of, would accomplish."

MR. SWAIN.—It seems to me that one reason why western cities have failed to have a standard is because drills and reamers, and all standard tools used to do the work have been available in the Eastern States; but if a western shop wants to fit a piece of work the first thing done is to drill a hole and fit a piece into the hole. They go into the blacksmith's shop and have a drill hammered out to the nearest size that can be got from the scale, sometimes it is turned and sometimes ground on a stone, to fit the work ready to drill. But in the Eastern States you can go into a store and get standard drills and reamers. They have a better chance to attain standard work. It seems that a set of gauges are useless in a shop without having the means and tools also to do the work. In Palmer & Rey's shop we are using, almost exclusively, Richard's standard gauges, and we find them very satisfactory. We are using them in conjunction with the Morse reamers."

Q.—"In the armories, do they follow the standard gauge in minute measures?"

A.—"I think the original standard was obtained from Whitworth & Co., and duplicates made of varying degrees of accuracy. The cheaper ones were given out around the shop, while the better ones were kept in the different departments of the main office, and in the fitting of the gun parts every foreman has two gauges. One is an allowance for error, the other a small one, and the piece of work must be fitted so that it will not go through the small gauge, but must go through the larger one. In that kind of work a certain amount of error must necessarily be allowed, although the error in gun work is very slight because the pieces are small. As they increase in size the difficulty of duplicating is very much greater. Although one can have a standard gauge for boring a cylinder or anything else, it is difficult to keep a tool of such size that it will duplicate any number of them and keep absolutely to that standard."

The Elgin Watch Factory uses the metric system and sight gauges entirely, they are not dependent upon the condition of the workmen, that is, whether a man feels well or not in the morning. The difficulty of calipering a piece of work is this, the same man will caliper differently at different times. The sense of

feeling varies. I think two cylinders held up to the light will show almost as fine an error by sight as can be found through the sense of touch."

MR. WOOD.—"I am not in the ranks of mechanical engineers, I am only a contractor. Still I have a profound appreciation for their work. Societies in the east, analogous to the Technical Society, have done a good deal toward establishing uniformity in some lines of work, and I do not see why they should not accomplish something in that direction. I believe it would be well for the officers of this Society to prepare a circular, worded in the technical lore of Mr. Dickie or Mr. Richards, or a committee including those members, and have these circulars distributed among the various shops in the city and among those directly interested in this matter, so as to get an expression of opinion from them, and the arguments from their point of view. I do not see why this Technical Society is not competent to draw their fire and to agitate the subject, and to keep it up until some uniformity is secured. I will say, as a representative of a contracting firm, that I would welcome most gladly a uniform standard in any work. Now, we have hardly a uniform standard in anything."

MR. DOW.—"Unfortunately I am one of those manufacturers who have so many different gauges to contend with, or rather I did have them some six or seven years ago, so that I found it necessary to take a positive standard. I used the Brown & Sharpe system of gauges for all diameters up to 24 inches. I must say that in my own works I do not suffer any inconvenience. But I know, in general, the shops in this City do not do their work on the gauge system, and as a general rule such a system is very badly needed. I think the only plan is to do as Mr. Dickie says, get the proprietors together and work in harmony and good feeling."

MR. RICHARDS.—"There has been very little said about the economical part of the problem, the saving that may be effected by this system. I don't know that anybody is prepared to give any statistics about it, only by general observation. There is an economical problem lying at the bottom, in the matter of tools and cost of doing work."

MR. DICKIE.—"It is not so much in obtaining gauges and having them, as in the working thereof. Little mistakes are made and rectified, and machines go out without any record of these corrections, that makes a great deal of trouble—a thing is supposed to be

made to a gauge when it is not. I believe that gauges in many kinds of work can make a saving of at least 60 per cent."

MR. BEHR.—"Mr. Richards spoke about machines manufactured for South America, and if made to a standard would sell more readily. I suppose it would be necessary to use the metric system, as in France and Germany, and all European countries where this system is used."

MR. DICKIE.—"All the work we have got from Krupp has the Whitworth threads, unless specially ordered otherwise. I noticed that the French specifications all call for Whitworth threads. In some work that we procured for the *San Francisco* we had to renew the screws after they were received here. So we are just as badly off with the work of other people as other people are with our own."

MR. RICHARDS.—"I was not aware that the English standard is used in France and Germany for threads. I suppose it is done for commercial expediency. In places like South America and distant parts of the world, the English have gone there first, and the measures generally had to conform to their standards."

REGULAR MEETING, FEBRUARY 5th, 1892.

PROCEEDINGS.

MINUTES.

The meeting was called to order at 8:30 P. M., by Mr. C. E. Grunsky, Chairman.

The minutes of the last regular meeting and of the annual meeting were read and approved.

The following new members, having been balloted for, were declared elected:

Theodore Wetzel, Supt. Derbec Mine.....North Bloomfield, Cal.
L. C. Russel, Mechanical Engineer.....San Francisco, "
Frank H. Olmstead, Civil Engineer.....Riverside, "
Geo. P. Cramer, Surveyor, (Junior).....Seattle, Wash.
J. F. Morrow, Surveyor, (Junior).....San Francisco, Cal.

The following names were proposed for membership and referred to the Board of Directors:

Bernard Bienenfeld, Civil Engineer, of San Francisco; proposed by Ross E. Browne, Frank Soulé, and Hermann Kower.

Conrad Eimbeck, Civil Engineer, of Guaymas, Mexico; proposed by Hubert Vischer, Luther Wagoner and Carl Stetefeldt.

D. C. Henny, Civil Engineer, of San Francisco; proposed by Hubert Vischer, Geo. F. Schild and John Richards.

Alexander M. Reynolds, Civil Engineer, of Seattle, Washington; proposed by J. P. F. Kuhlmann, H. C. Behr and Otto von Geldern.

Arthur H. Sanborn, Ass't City Surveyor, San Francisco, proposed by H. D. Gates, Otto von Geldern and Geo. F. Schild.

Mr. N. S. Keith invited the members to visit his place of business to inspect a new electric drill. He stated that the time between 10 and 11 A. M. would be most suitable, during the coming week.

A communication from Mr. Luther Wagoner was read, in which he donated to the Society a complete set of Van Nostrand's *Engineering Magazine*, consisting of thirty-four bound volumes, and expressing the hope that similar donations would also be made by all who have the Society's welfare at heart.

The Secretary was instructed to communicate with Mr. Wagoner, and to express the appreciation of the members for this valuable gift.

Mr. D. C. Henny, Civil Engineer, then read an interesting paper, treating of "Water Pipes built of Wooden Staves," a subject comparatively new to the profession, which caused considerable discussion, entered into by a number of prominent members.

Two visitors, Prof. Marx, of the Leland Stanford, Jr. University, and Professor Kernot, of the University of Melbourne, Australia, also spoke briefly on the same subject.

(This paper, with its discussion, will be published in the next number of the Transactions.)

DISCUSSION OF TOPICAL QUESTIONS.

The topical question submitted for discussion was announced by the Chairman :

What is the effect of wind on the mean velocity of a river?

The Secretary then read the following communication from the author, Mr. D. E. Hughes, in order to incite general interest in the subject :

CONCERNING SURFACE SLOPE OF WATER, DUE TO WIND; AND THE EFFECT OF IT ON THE MEAN VELOCITY OF A STREAM.

Not till after this question was proposed did the writer learn that anything would be required of him, or something easier would have been sought; yet, in preference to retreating, this paper is offered, with the sole plea, however, that it may provoke discussion.

Wind imparts to water a nearly horizontal force, which, taken with gravity, furnishes a resultant out of plumb, thus causing a surface slope. This wind force is due to what, for want of a better name, is called fluid friction, and to a component of wind pressure on an oblique plane. This plane is furnished in the windward side of waves, by the inclination that the surface of the water has already attained, and, maybe, by virtue of a dip of the wind.

Fluid friction and wind pressure are both quite generally assumed to vary as the square of the velocity (v^2). Gravity on a column of water varies as the depth (d). If nothing more were taken into consideration, it would appear that the slope equals $k \frac{v^2}{d}$ where k is a constant.

Wind acts more on the upper portion of a body of water than it does lower down. In consequence of this, is there, in addition to the undertow of the waves, any under-current windward caused by super-elevation of the general surface at the leeward side? If so, then the above expression for slope must be diminished by what? Probably some function of depth, and velocity of the wind.

The writer does not deny that there is an underflow due to the existing differences of head, or, rather, to a tendency to a still greater difference; but he thinks, without much investigation, however, that

in case of shallow water, where viscosity and bed resistance are relatively great, the negative quantity, occasioned by the undercurrent, is small in comparison with the positive term, and, since wind slopes on water of considerable depths are trifling anyway, the opinion follows, that for most practical purposes the simpler formula will be sufficiently correct, if it is adjusted to water 4 feet deep and wind of 40 miles.

The coefficient required for this must be supplied from observation. An approximate one is deduced from the following imperfect data.

In the southern part of the *Colusa Basin*, which is a depression flanking the right bank of the Sacramento River, north of Grafton, there is an area about 9 miles long, which is very nearly level lengthwise, and practically bounded at the ends by levees. Its direction is that of the south wind, and "northers," which come there from a little east of south and west of north, respectively.

Last winter it was observed that a strong south wind raised the general surface of the water at the north end 6 inches on a stake some distance from the levee where the water, on a still day, was 4 feet deep.

The ground being level, the slope lengthwise of the trough was probably not quite uniform owing to change in depth caused by the slope, but the excess in the half where the depth of the water was diminished so nearly atoned the defect in the other half that the average for the whole was practically the same as that obtaining at the center, where the depth of 4 feet was not altered. The width of the water, averaging more than 3 miles, was not uniform; but its figure was so nearly symmetrical, with respect to the mid-cross-section, that the depression of the surface at one end is assumed equal to the elevation at the other, or 6 inches, making a total fall of one foot in the length of 9 miles.

I do not know what the velocity of the wind was, but make the assumption (and the constant is at the mercy of it) that it was 40 miles per hour.

The levee on the north end of the 9-mile trough does not extend clear across, but turns to a northerly direction, leaving a channel west of it. Up this channel about 1½ miles, where the ground is a half-foot higher, another observer noted as follows: "Depth in calm a little less than four feet; surface depressed by strong north wind, 8 inches."

It may be noticed that the slope found, will, when reversed and extended 1½ miles, just fit this case.

These observations were not made with a view to their technical value, but are, nevertheless, trustworthy as far as they go.

I think that a little of that slope was borrowed from the tendency to a greater one in the shallower water along the sides, and that if the 4-foot water had been kept separate from the rest by parallel levees, the surface fall between them would not have exceeded one-tenth foot per mile. Putting this in the formula it becomes:

$$\text{Fall in feet per mile} = \frac{(\text{Velocity of wind in miles per hour.})^2}{4{,}000 \text{ times the depth in feet.}}$$

As before mentioned, this rule, even if the above data were correct, is right only for a 4-foot water and a 40-mile wind. For a less depth it does not give quite enough, while for deeper water it shows too much.

It is desirable that much and varied data on this point be obtained, not only to test this coefficient, but in order that the elements of a better formula may appear. This rule indicates that the *slope* of ordinary rivers is not appreciably affected by wind, while water 6 inches deep may be driven entirely out of a pond by a not very uncommon wind, if the bordering ground rises not faster than 8 inches to the mile; and that a stream 2 feet deep, falling 2½ inches per mile, will be stopped by a 40-mile wind, unless its feeder can furnish it more head.

Now suppose a canal 4 feet deep with a fall of 0.4 feet per mile, and a 40-mile head wind. How shall we calculate velocity? Will it be proper to simply reduce the 0.4 fall to 0.3, and use that as though no wind were blowing; or should we calculate velocity due to 0.4 then to 0.1, and take the difference; or may we suppose the wet perimeter to extend clear around, thus diminishing the hydraulic radius, and use some averge coefficient, if so, what slope must we take, 0.3, 0.4, or 0.5; or must the problem be approached from an entirely different standpoint?

The last paragraph above is inserted only to enumerate the plans that may suggest themselves before the proper one is determined upon.

The Chairman stated that this question would remain open for discussion, and that communications from any one in the Society were invited in order to examine into a subject that promises to be of considerable interest. He hoped that it would be brought up again in the near future, and advised the circulation of Mr. Hughes' statements among the members.

Adjourned. OTTO VON GELDERN, *Secretary.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME IX. No. 2.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

WATER PIPES BUILT OF WOODEN STAVES.

BY D. C. HENNY, MEM. TECH. SOC.

[Read Feb. 5, 1892.]

Wooden stave pipe has been so largely used in some of our western states, notably Colorado, for carrying water for domestic supply and irrigation, that it is surprising to find this kind of pipe comparatively little known in California.

The title of this paper indicates my intention not to discuss wooden pipe in general, and if I refer to bored log pipe here, it is because experience with it extends over a longer period, although the use of wooden stave pipe is by no means new. That a century and less ago hundreds of miles of bored pipes have been used in England and in some of our eastern cities, before there was a demand for high domestic pressures, is well known. But what is perhaps not so generally understood, is that their abandonment has not been due to any supposed or real unfitness of clear sound wood as a water carrier, but to mechanical causes, involving both its strength and its cost. And it is for this reason that their use has been resumed, in such shape and with such improved methods of manufacture, as to make it meet the requirements of the present time.

The remarkable lasting qualities of wood, when constantly under water are well understood. A wooden pipe filled with water, under pressure is, as far as the wood is concerned, in the same condition as if it were submerged, even though the soil in which it lies be

perfectly dry ; provided of course that the thickness of the wood is not excessive, so that the water can penetrate it for its full thickness and thus maintain a condition of complete saturation. The experience with bored log pipe demonstrates this fact. Numerous are the instances of bored logs, dug up after many years of service, and all such pipes were sound when taken up, unless they had been suffered to remain in the ground long after they had been abandoned.

The principal qualities which material for pipe should possess are water-tightness, smoothness of interior surface, and durability ; great strength is not necessarily one of them, for although the strength to resist inside pressure may be vested in the material of the shell itself, as in uncoated iron and steel pipe, it may also be concentrated upon the outside surface, or spread around it, and thus be kept from contact with the water. In fact, when we consider the great care exercised in coating iron and steel pipe it is apparent that the coating forms the real shell, the material back of it simply serving to support it. This is especially evident in the cement lined pipe, which has been much used in the East, the cement having no strength of its own against bursting. The necessity of coating iron and steel pipe is, of course, due to their being short lived materials when in contact with the water, and for this reason undesirable for pipe shell in the sense the word is here used, although eminently fit to support it. Use wooden staves instead of asphalt varnish for a shell, concentrate your metal in the most advantageous form around it, and you have the wooden pipe of which I am to speak. I do not mean to imply, however, that in this manner the stave pipe was evolved in practice, for it has too close an analogy with the ordinary water tank and barrel to doubt that these were its real progenitors.

DESCRIPTION OF PIPE.

This pipe may be considered an indefinitely extended horizontal cylindrical tank. The staves are dressed like tank staves, the flat sides to the cylindrical surfaces conforming to the inside and outside diameter of the pipe, the edges to radial lines. Some pipes have been built with slightly V shaped edges, male on one side, and female on the other, which offers some advantages in its construction, but does not give as firm a bearing of one stave upon the other. Thus far the pipe and the water tank are exactly alike. The difference enters with the necessity, with pipe, of joining the butt ends of the staves. Joints are generally weak places in all pipe, and it is an advantage with this pipe, that the staves can be

made to break joint so that this weakness may not occur at the same point, but be distributed along its length; in this manner the pipe becomes one continuous stiff tube, with no tendency to settle in one place more than in another. To find a sure and simple method to make the butt connections tight under pressure, Mr. C. P. Allen, some nine years ago, while chief engineer of the Denver Water Company, being called upon to construct a 48-inch pipe line for his company, instituted a series of experiments, the results of which he finally patented. It is under this patent that most of this pipe has been built.

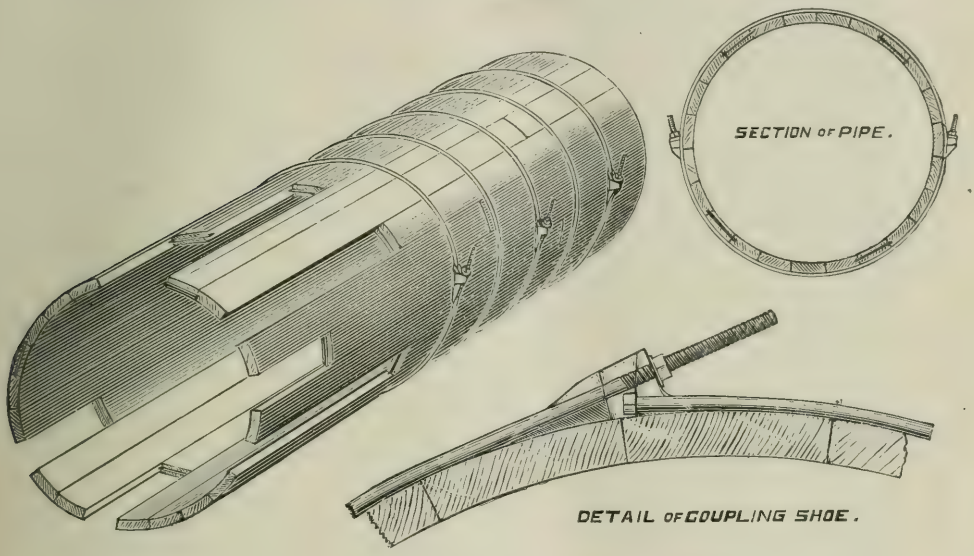

FIG. 1.

His experiments covered both the best butt joint and the most practical form of bands and shoes. The ordinary tongue and groove was tried, and so were other simple wood connections. Whether it was due to the difficulty of cutting and preserving the sharpness of all corners and edges; whether to slight imperfections of the wood at the ends of the staves, such as small shakes and cracks; to a greater deflection under pressure of the stave at the joint, than of the adjoining stave where no joint occurs, or to other causes; the pipe showed an aptness to leak at the intersection of the seam and butt joints, in other words, at the corners of the staves. It was not until the simple device of

inserting a piece of band iron in the end of the stave was resorted to, that the problem was satisfactorily solved. As it is now used, the plate is usually cut of No. 12 band iron, one and one half inches in width. The stave is slotted in the ends to receive these plates, as shown in Fig. 2.

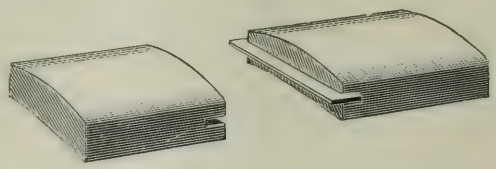

FIG. 2. VIEW OF BUTT JOINT.

Now imagine a joint without the plate; the space left for it is smaller in all directions than the plate itself. It is less wide than the thickness of the plate, so it fits snug, and the edges of the plate penetrate the wood, sidewise in the bottom of the slot, and endwise in the side of the adjoining staves. It carries the contact of stave against stave, as far as water tightness is concerned, back ¾ of an inch from the end of the stave, thus neutralizing the effects of such imperfections in the wood as do not extend further than the depth of the slot, and secures an equal deflection of the stave, at the butt, and of the adjoining staves. The stave is thus square at the ends, having no projecting corners which can be easily damaged. And although the staves are slotted at the mill, it is no slight advantage that this slotting can be easily done with a common hand saw on the work, in case staves are cut.

The thickness of the stave depends upon the pressure of the water, the size of the pipe and the load upon it. The thickness required for various pressures must be determined by experiment. I know from experience that redwood of a thickness of 1⅜ inch shows no sign of the water oozing through under a pressure of 165 feet, and I am inclined to the opinion, seeing that every annular ring in redwood contains a very hard, flinty shell, of which there are some 20 or 25 to the inch, that that thickness will prove tight under much higher pressure. The diameter of the pipe and the superincumbent load determine the thickness of the staves, which act as an arch to support the load.

In attempting to calculate the required thickness of the wood for various diameters and top loads, we meet with the obstacle that the initial compressive strain in the wood, caused by the tightening of the bands, being one of the main factors, is rather uncertain and

hard to determine, varying along the length of the pipe with the number of bands, and with the degree of swelling of the wood; I therefore take experience and experiments to be a safer guide.

The first wooden pipe built in Denver was 48 inches in diameter, and the staves were cut from 2-inch lumber, running about 1⅝ inch in thickness. Where this pipe was laid in good material it preserved its circular section, but part of it was laid in soft muck, and there the pipe became somewhat elliptical, in some places, with the long axis horizontal, in others vertical, as the loads on top or those on the sides were in excess. By dumping slag from the smelters, either alongside or over the pipe, it was restored to its original shape without trouble. This shows that here the safe limit for 2-inch timber was nearly reached for pipes which are to be covered two or three feet.

A 72-inch pipe was built on the Maxwell grant, in New Mexico, of 3-inch lumber, running about 2½ inches after dressing, and no flattening was observed.

The banding of the pipe is done in a manner similar to tanks, except that instead of flat iron bands, round steel is used. Herein lies the main difference between the stave pipes which have for years past been built in the East, and those which have during the last eight years been constructed in the West.

A pipe line, that at the time attracted considerable attention, was built by Mr. Fanning, for the water works at Manchester, New Hampshire, for water power purposes. It is six feet in diameter, banded with flat iron, and Mr. Fanning writes that it is in good condition. It was built in 1874, and is described in his treatise on water supply engineering.

The round form of bands is advantageous in as much as the life of the pipe is that of its shortest lived parts, which are the bands, although it is of course possible to replace old bands by new ones without abandoning the timber shell. Now the circle has a maximum area with a minimum of circumference, and thus offers the least possible surface to corrosive influences. Besides, the round form offers special facilities for joining the ends so they can be tightened with a single nut.

The question may be asked: why, if round bands are economical on pipe, they are not commonly used on tanks? This is due to the tapering shape of tanks, which allows the bands to be cut to exact lengths and riveted, and to be driven down from the narrow top of the tank without any other arrangement for tightening, the

same as with barrels. It cannot be denied that a flat band has a better bearing on the wood than a round one, but that this larger bearing is entirely superfluous, I will endeavor to show further on.

These rods are, before being bent, simple straight bolts, with a head at one end and a thread and nut at the other, in length from three to five inches longer than the outside circumference of the pipe. They are bent on the work on bending tables, and then dipped in mineral paint or asphalt varnish, and hung up to dry several days ahead of the work of pipe laying. For large pipes two segmental bands are used, the rods otherwise becoming too long and heavy for easy handling.

The ends of these rods are joined together by means of a cast iron shoe, or saddle, of a simple form — several forms being in use. They are all shaped to fit the outside surface of the pipe for which they are designed. In each there is a shoulder for the head and a shoulder for the nut, the threaded end being made to lie over the head. Thus the strains on the shoe are not only as much as possible compressive strains, but they are all through the center line of the shoe, producing no tendency to twist, as is, for instance, the case with a casting in which the ends of the bands lie alongside each other. These castings can all be made at a low price per pound, there being no machine work about them.

CALCULATION OF STRENGTH.

To properly decide upon the diameter and spacing of the bands, we must understand the exact purposes for which they are put on. On a grade line pipe they serve the purpose of holding the staves together and securing the rigidity of the pipe and the tightness of the seam joints. There is an initial strain on the band when tightened, equal to the compressive strain in the wood. This strain is increased as the wood swells, when water is let into the pipe. The additional strain due to this cause, however, can never attain great proportions, as it increases very gradually, and is kept in check by the simultaneous adjustment of the fibre under the band. Finally, there is a strain on the band caused by the weight of the water from top to bottom of section, which may amount to about 16 pounds for 12-inch, and 2,074 pounds for 10 feet pipe, per lineal foot of pipe. Of all these strains, the one produced by the cinching of the bands is most important. In some cases the bands were spaced 18 inches apart with satisfactory results, on pipe under light heads.

For a pressure pipe we have to consider the bursting strain. No matter whether the shell be a mere coating of tar or asphalt, or a

lining of cement, or wooden staves, a certain area of iron or steel is required on the outside to resist these strains, and in the case of wooden pipe it remains to so divide it over bands of the right diameter, that the staves may receive support with sufficient frequency to prevent excessive deflection between the bands, and excessive indentation at the bands.

The distance between the bands for bursting strain is expressed by the following formula :

(1.) $$l = \frac{2\,S}{d\,P}$$

l being the distance from center to center of band in inches.
S " the admissible strain on the band in pounds.
d " the inside diameter of the pipe in inches, and
P " the pressure of the water in pounds per square inch.

The distance between the bands, which keeps deflection of the stave at its weakest point (that is the butt joint) within $\frac{1}{1000}$ part of the span from band to band, is :

$$L = \frac{25.6\,h}{\sqrt[3]{P}}$$

h being the thickness of the stave in inches. Therefore, the condition imposed by the deflecting of the stave is :

(2.) $$l < \frac{25.6\,h}{\sqrt[3]{P}}$$

I give this formula rather to show the relation between distance of bands, water pressure, and thickness of stave, than that I would unreservedly recommend it for use. While it is based on a modulus of elasticity in relation to bending of 1,600,000—as given by Weisbach for wood, generally, which may be too high in the case of redwood—on the other hand, the limit of $\frac{1}{1000}$, the span for permissible deflection, is arbitrary. Experience has so far shown that where seam leaks have been found, they were clearly due to imperfect lumber, imperfect milling, damage to the stave in handling, or insufficient cinching of the bands, and not to excessive distance between the bands.

To a possible crushing of the fibre under the band, I have already referred. Redwood is but slightly indented under a pressure of 1,000 pounds per square inch, and I find that a rod may sink into the wood so as to get a bearing of 60° along its circumference, indenting the wood to a width equal to its radius, without perceptible damage to its fibre. The safe resistance of the bands against the

staves thus being proportional to the diameter of the band, and the strength of the band being approximately proportional to the *square* of the diameter, it follows that if the required strength of the steel is distributed over four bands of one half the diameter, instead of being concentrated in one band of the full diameter, the safe resistance of bands against staves will be twice as large. Thus we can, by a proper subdivision, provide sufficient bearing for the staves. $\pi(d + 2h)$ being the outside circumference of the pipe, and r being the radius of the rod, it follows that $\pi(d + 2h)\, r \times 1{,}000$ equals the safe resistance, in pounds, of the bands against the staves. The pressure of the water against the staves is $\pi d P l$, therefore,

$$1000\, \pi\, (d + 2h)\, r > \pi\, d\, P l, \text{ or}$$

$$l < \frac{1000\, (d + 2h)\, r}{P d}$$

or substituting for l the value in formula (1)—

$$(3) \qquad S < 500\, (d + 2h)\, r$$

That this condition is readily complied with, is evidenced by the following instances:

$d = 12 \qquad h = 1\frac{3}{8} \qquad r = \frac{3}{16}$

$S < 1383$

S being 1143 pounds for $\frac{3}{8}$-inch rods, figured in the thread, with a factor of safety of 4.

$d = 20 \qquad h = 1\frac{1}{2} \qquad r = \frac{1}{4}$

$S < 2875$

S being 1960 pounds for $\frac{1}{2}$-inch rods, figured in the thread, with a factor of safety of 4.

$d = 54 \qquad h = 2\frac{1}{2} \qquad r = \frac{5}{16}$

$S < 9219$

S being 4600 pounds for $\frac{5}{8}$-inch rods, upset to $\frac{7}{8}$ inch, and figured in the bolt with a factor of safety of 4.

This shows that flat bands offer no advantage over round bands so far as indentation is concerned, since the larger bearing they provide is superfluous.

MATERIALS.

The bands used are of mild steel with an ultimate strength of 70,000 pounds to the square inch for ⅜-inch rods, 65,000 pounds for ½-inch rods, and 60,000 pounds for larger diameters. When the rod is not upset, as is the case with the smaller diameters, we must figure the strength of the rod in the thread; and, it should be borne in mind, that since the strongest part of the steel lies on the surface, and is cut away by the die, the average strength of the remaining material is less than that of the full rod. I therefore deduct from the strength per square inch, in the case of ⅜-inch and ½-inch rods 10 per cent., and for larger sizes 5 per cent. Thus we get for the strength of bolt, in the thread, per square inch:

⅜ inch	63,000 pounds
½ "	58,500 "
Larger Sizes	57,000 "

The wood that has been used in the pipe lines in Colorado is redwood, Texas pine, and, in some instances, native lumber. In drawing up specifications for cast iron pipe the engineer calls for the best material, and does not admit blow holes, flaws, or other imperfections. There is no reason why the same care should not be exercised with wood; only well seasoned and perfectly clear, close and straight grained lumber, free from pitch, and with as little liability to swell and shrink as may be, should be specified. And there is no other, among the soft woods, that comes up to these requirements so well as redwood does; a fact which is beginning to be appreciated even in Colorado, where this kind of wood, owing to high freight charges, is quite expensive, the difference in price as compared with Texas pine being no less than $15 per thousand.

It needs no arguing that the lumber should be milled with the greatest exactness, both as regards the section of the stave and its ends. The lumber should be shipped in box cars, and at the point of destination should be piled up and covered, and not strung out along the trench until ready for immediate use.

The saddles or shoes should be of the best grade of cast iron, free from flaws, blow holes, or other imperfections. They should be rattled in a rumbler until they are bright and free from sharp edges, splints and tags.

MANNER OF CONSTRUCTION.

The erection of wooden pipe requires skillful and patient labor. The work proceeds about as follows:

U shaped, outside forms, usually of bent gas pipe, are put on two-inch blocks, and in these are laid the staves forming the lower

half of the pipe. Then inside forms are put in position, on which are placed the balance of the staves, completing the circle. The staves are so placed that the end of one stave projects beyond, or falls back, 18 or 24 inches from the ends of the adjoining staves, so that the end of the pipe, during construction, presents a jagged appearance.

The bands are then put on and tightened, whilst the pipe is rounded out. After all bands are put in place at the proper distances and are securely cinched, this first section of pipe is ready to be extended in both directions.

The clips or metallic tongues are put in the slots, and the staves of the next section are put in place the same as before. The bands are put on, and whilst they are being tightened the staves are driven up with a heavy sledge and driving stick. The pipe builders are followed by back cinchers who give the final cinch to the bands. If the pipe is built in the trench, they in turn are followed by back fillers who tamp the earth under and alongside the pipe, and cover it. In this way one gang builds from 75 to 175 feet per day. On long pipe lines a number of gangs are put to work, and where they meet a buckle is made, by fitting the staves and springing them in. Connection with cast iron pipe or gates is made by means of special spigot and bell pieces, having large and deep bells into which the wooden pipe enters. The space between pipe and bell is caulked with oakum, or run with lead and caulked.

There should be air and check valves when there are summits on the pipe line for the emission and admission of air. The nipples for these valves are screwed in a hole in the wood, bored with a smooth cutting bit or auger. It is well to use lock nuts and oakum packing in connection with these nipples, although not necessary. Ordinary corporation cocks for taps may be screwed in, in the same manner.

For short irrigation siphons it is important, in order to save loss of head, that the entrance be made easy, and it is a very simple matter to give the end of the pipe a funnel shape, by inserting between the regular number of staves others planed down to a point.

It is suprising how easily this pipe can be made to follow, in a general way, the undulations of the ground, although the curvature to which it can be laid is, of course, limited. Thirty inch pipe readily follows curves of a radius of 250 feet.

CARRYING CAPACITY.

To my knowledge no accurate measurements have been made of the carrying capacity of wooden-stave pipe. I use the Kutter form-

ula, putting the coëfficient of roughness n at 0.010, which Kutter, for open flumes of well dressed timber, states to be 0.009. Since it presents no joints or rivet heads to the current, and is otherwise perfectly smooth, it is plain that its carrying capacity must be greater than that of sheet iron or steel pipe, and that it greatly exceeds that of cast iron pipe. The inside remains smooth and clean, and there need be no fear of the capacity gradually diminishing.

COST.

The cost of this pipe is in the nature of the case closely dependent upon the pressure. Graphically we can represent the connection between cost and pressure, both for wooden and sheet-iron pipe, as shown in Fig. 3.

These diagrams have not been drawn to any scale or for any special size pipe, but are merely intended to illustrate the characteristic increase of cost with increase of pressure for each kind of pipe. It is plain that the shaded triangles represent cost of material required over that which is called for by the bursting strain for purposes of stiffness and rigidity. Although wooden pipe under high pressure may require as much, or even more metal than sheet-iron pipe, the reverse is the case with low pressure, as is still further shown in the following table:

	WOODEN PIPE.				SHEET-IRON PIPE.		
Diameter Pipe.	Diameter Bands.	Weight Metal	Safe Pressure. Factor of Safety 4.	Gauge Iron	Weight Metal.	Safe Pres're. Working Strain 10,000 lbs.
		Bands every 12 inches				
12	⅜ inch Straight.	2.5 lbs.	15.8 lbs.	No. 16	11.25 lbs	81 lbs.
16	⅜ " "	2.9 "	11.9 "	" 16	14.5 "	61 "
20	½ " "	6.0 "	16.2 "	" 16	18 "	49 "
24	½ " "	7.3 "	13.5 "	" 14	27.25 "	52 "
30	½ " "	8.6 "	10.9 "	" 12	44 "	54 "
36	½ " "	9.9 "	9.0 "	" 11	58 "	50 "
42	½ " "	11.1 "	7.7 "	" 10	74.5 "	48 "
48	½ " "	12.2 "	6.8 "	" 10	85 "	42 "
54	⅝ " Upset	23.6 "	13.2 "	" 10	95 "	33 "

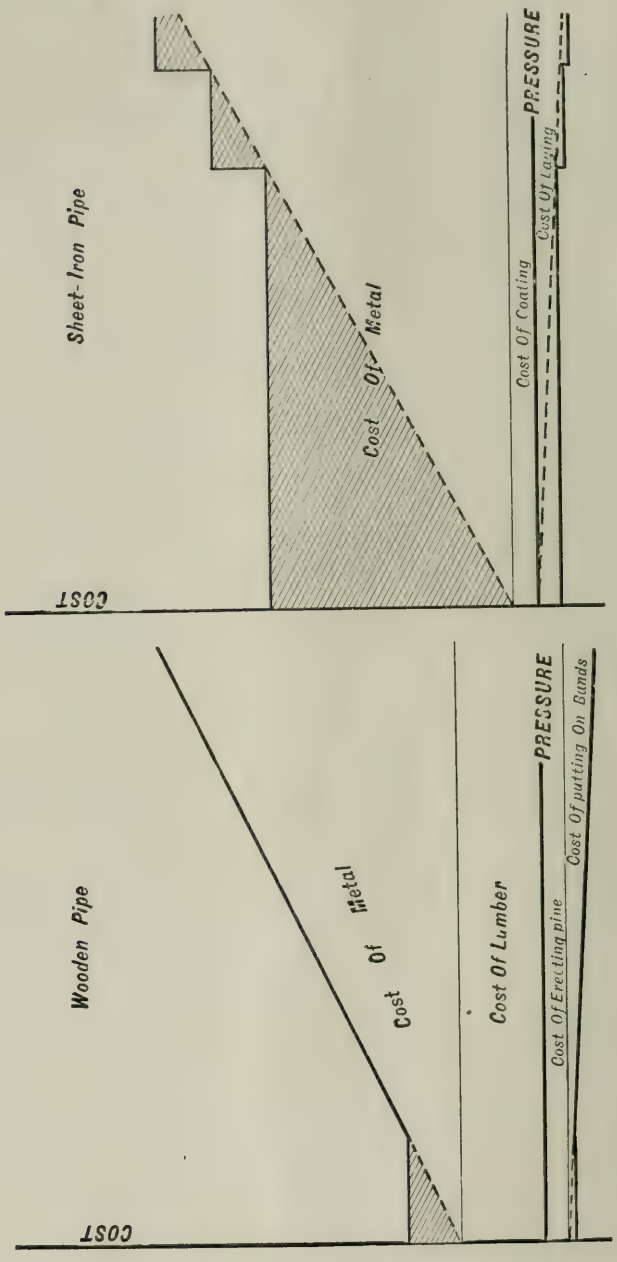

FIG. 3.

COMPARATIVE COST OF WOODEN AND SHEET-IRON WATER PIPE FOR VARYING PRESSURES.

The gauge of the sheet iron has been assumed as light as only the most favorable circumstance will allow, and the weights are based on straight pipe, with slip joints, and exclusive of the weight of the coating.

Beside the mere comparative weight of metal there enters a factor of comparative cost per pound. It is true that the actual cost of working sheet iron may be brought down to a low figure, but it requires expensive machinery, working only part of the time, and depreciating all the time. For the manufacture of bolts, such as are used on wooden pipe, no special machinery is required, bolts being a

FIG. 4. 37-INCH PIPE AT DENVER, COL.

staple article in the market. And the tools needed for erecting the wooden pipes are few, simple and cheap. It must also be remembered that the comparison of cost should take into account the comparative carrying capacity, which, where prices seem equal, makes wooden pipe between 5 and 10 per cent. cheaper per gallon of water carried than sheet iron.

FIG. 5. 14-INCH PIPE AT PROVO CITY, UTAH.

As it bears on this subject, I wish to quote from a report made about a year and a half ago to the Pueblo Gravity Water Co., by one of our members, Mr. James D. Schuyler.

"I have recommended the use of 5,630 feet of 30-inch, and the remainder, 70,140 feet of 24-inch pipe, to be made of California redwood staves, built continuously in the trench and banded with round steel bands. This recommendation has been made for the following reasons:

First.—After thoroughly investigating the history of wooden pipe as laid for seven years past in Colorado, and after examining a number of lines in use, I have come to the conclusion that if the bands are properly coated and the pipe kept full of water it is practically indestructible, and certainly has a longer life than sheet iron or steel riveted pipe.

Second.—The interest on the *difference* in cost between wood and cast iron pipe of the same capacity will replace the wood pipe every ten years, which I think is but a fraction of the life of wood pipe, and therefore it would be a prodigal waste of money to put the amount of capital necessary to lay cast iron mains into the enterprise.

Third.—The wood pipe is cleaner, does not become foul, does not rust, does not fill with tubercles that diminish the capacity year by year, has no yarn to rot and contaminate the water, will not break by settlement, will not burst so readily under water hammer, and so long as it lasts is, in every respect, cleaner and more desirable.

California redwood is so much better adapted to that purpose than any other wood available, that I recommend that material."

For the 16 miles of 30-inch wooden pipe, built by the Citizens Water Co., of Denver, two years ago, the comparative figures of cost, roughly stated, are about as follows:

Actual cost, wooden pipe	$160,000
Estimated cost, riveted iron pipe	333,000
Estimated cost cast-iron pipe	717,000

This line of pipe is almost entirely under a pressure varying from 50 to 220 feet. It was built of Texas pine. If redwood had been used, as it will be for all new pipe lines now contemplated by this company, the cost of the wooden pipe would have been about $185,000.

PIPE LINES IN USE.

Besides a number of short irrigation siphons in Colorado and New Mexico, varying in diameter from 24 to 72 inches, there have been built, during the last eight years, the following pipe lines, arranged in chronological order:

3.2	miles	48	inch	pipe	Denver Water Co.
5.75	"	37	"	"	" " "
1.	"	30	"	"	" " "
1.25	"	24	"	"	" " "
3.	"	12	"	"	" " "
2.	"	25	"	"	" " "
0.5	"	48	"	"	City Ditch, Denver.
0.75	"	30	"	"	Cheyenne Water Works.
1.78	"	24	"	"	" " "
1.13	"	24	"	"	Irrigation purposes near Denver.
3.	"	12	"	"	East Denver.
0.8	"	54	"	"	Irriga'n siphon, Bessemer Ditch, n'r Pueblo, Col.
5.	"	24	"	"	Ogden (Utah) Water Works.
16.	"	30	"	"	Citizens Water Co., Denver.
3.13	"	12	"	"	Aurora Water Works, near Denver.
6.5	"	30–18	"	"	Perris Water District, Cal.
3.75	"	14	"	"	Provo City (Utah) Water Works.

The pipe lines at Cheyenne were constructed in a poor manner and of cheap material, and have not given satisfaction.

Note.—The pipe built for the Perris Water District is slightly different from the other pipes mentioned, in that it has the edge of the staves dressed in a V shape, instead of flat.

CONCLUSION.

Before a body of engineers it is unnecessary to state to what purposes this pipe is adapted. Yet I wish to call your special attention to its comparative cheapness under light heads. Long gravity mains for domestic supply can often be located so as to keep the pipe close to the hydraulic grade line. It offers advantages, regardless of its cost, which commend it particularly to irrigation engineers. And that it is applicable to the development of water power and to hydraulic mining will be readily understood.

DISCUSSION.

PROF. KEITH.—The paper read this evening recalls to my mind that in 1863 I had occasion to build a species of wooden pipe for carrying water through a mill building on Clear Creek, near Black Hawk, Colorado. The building stood on a side hill, and before the pipe was used the seepage from the ditch, which was first used to convey the water, was a source of annoyance. The pipe was built with tapering ends, so that one length fitted into the mouth of the next length of pipe. The bands were made to different sizes, and driven on to the pipe to sustain it. This pipe though

a somewhat crude device answered our purpose excellently, did not leak at all, and was in use for the four or five years I was there, and may be so still."

PROF. SOULÉ— "What care is taken to place bands over the joints where the iron plates are inserted?"

MR. HENNY.— "The pipe is built, more or less, in sections, and at places where the joints come we usually put one extra band, but we do not pay any attention to the bands being placed right over the joint."

MR. ALLARDT.— "How do you manage where pipe lines branch or cross?"

MR. HENNY.— "Cast iron specials are used with large and deep bells. The wooden pipe enters the bell, and the space between the pipe and the bell is caulked with oakum or with lead."

Q.— "How long do you make the staves?"

A.— "All the way from 12 to 20 feet."

Q.— "Is it necessary to have special machinery for making staves?"

A.— "We have special machinery for cutting staves for tanks; all that is required besides is machinery for slotting the ends."

PROF. SOULÉ.— "Did I understand you to say the pipes remain perfectly clean and free from vegetable growth or fungi?"

A.— "Yes. Most vegetation in the water requires light, and of course that is excluded."

Q.— "Have you ever noticed any special eroding or working away of the wood after pipes have been in use?"

A.— "Our experience with this stave pipe is not long enough to say. I have heard of 4-inch bored, log pipe that when taken up measured 5 inches. I suppose, however, that such wearing away takes a long time, a high velocity of the water, and presumably grit or sand in the water."

Q.— "Do you put any preparation on the wood, inside or outside, to preserve it?"

A.— "No sir."

Q.— "Do you prefer seasoned wood?"

A.— "Yes, in all cases, to prevent shrinkage after it is milled. Most of the wood is kiln dried."

Q.— "The best form of stave, after all, is the straight edge, is it?"

A.— "That is my opinion. We have never had any trouble with the seam joints, except where one could distinctly see some

defect in the stave, but experience has shown that the pipe must be carefully built to be thoroughly tight."

Q.— "What is the smallest size of pipe made of staves?"

A.— "The smallest size is 12 inch. I am now building at the works some 6-inch pipe. I have used staves out of one-inch lumber reduced as low as half an inch in thickness at the joints, and it makes a very stiff pipe."

Q.— "I suppose from that size up you can build as large as is required for practical purposes?"

A.— "A seventy-two inch pipe line built on the Maxwell Grant is the largest constructed so far, but there is no difficulty in building larger diameters if required."

MR. ALLARDT.— "Has any of this pipe been used for sewer purposes?"

A.—"Not as far as I know."

Q. "In a general way how does the cost, including the very large pipe, compare with the cost of sheet iron, or sheet steel?"

A.— "The cost of this pipe is dependent upon the pressure. Ten feet pipe, built of 4-inch lumber, banded with ⅞ steel bands 12 inches apart, is listed, including laying, at $13 a foot. Twelve-inch pipe with bands every foot at 80 cents, laid. The freight, if the pipe were to be used some distance from San Francisco, would be added, that is, on the lumber. For Eastern points this would be partly balanced by a saving on freight on the bands. The bands are sent direct from the factory to the place of destination, so the wood from San Francisco and the iron from the East meet at the work for the first time."

Q.— "Is it well determined that the wood does not rot on the outside of the pipe?"

A.— "Mr. Hull, an engineer in Connecticut, having built a good deal of this pipe, writes, after 40 years of experience with wooden pipe, that if the pipe is laid above ground and kept full of water its life would be about forty years, but if laid underground and covered over he considers its life indefinite, there being no rot to it."

PROF. SOULÉ.— "I have a piece of bored log pipe which was buried in the ground for 15 years, and used for carrying water for domestic purposes. You can scratch the outside anywhere, and the redwood is perfectly sound. The bore I think is two inches, and the log is about 4 inches square. I mention it simply to show the durability of the wood. It was not decayed in the least. I think, in this case, the wood, while the pipe was in use, was completely saturated with water."

Q.— "How are the bands protected?"

A.— "They are coated with paint or asphaltum. In case the bands should rust off in the course of years, new bands could be put on between the old ones, and the staves saved."

Q.— "Have you had experience with these pipes when laid on the surface of the ground?"

A.— "No sir, in Colorado these pipes are laid underground to avoid freezing of the water in cold weather."

Q.— "Is the wood surfaced on both sides?"

A.— "Yes sir."

Q.— "How much does the mill charge per thousand feet, board measure?"

A.— "Thirty-three dollars."

MR. VISCHER.— "I would like to ask Mr. Henny whether he has ever examined wooden pipe carrying water, to determine to what depth the wood was saturated with water?"

A.— "I have examined pipe with 1⅜ inch of shell, under nearly all pressures up to 165 feet, have cut into the pipe and found the wood looked damp, but did not show any signs of water oozing out."

MR. VISCHER. — "This pipe would, I think, derive certain advantages from the smoothness of its inner surface, in a capacity to withstand freezing of the water carried by it, when exposed to great cold. This is often a serious drawback to the use of iron pipe in cold climates, especially where supervision of the line is difficult. Freezing of the water is generally not directly brought about by the water being frozen at the point where stoppage takes place, but by the lodging of "scum" or "float" ice against surface obstructions in the pipe, which form initial points from which, by subsequent accretion, the whole area becomes closed. My experience was with iron pipes not larger than 8 inches diameter, and larger pipes, probably, are less liable to stoppage by freezing. However, the smooth and uniform inner surface should be an advantage, besides the greater thickness of the wooden shell of itself aiding in resisting cold. I think wooden pipes might be laid at less depth than iron, which advantage is often material when frozen pipe lines have to be hurriedly uncovered.

The correct thing is, of course, to put the pipes deep enough in the ground from the first, so that freezing will not take place, but this is not always easy to accomplish. Merely laying pipes below the frost line is not a guarantee against their becoming frozen.

In case of freezing, the remedy usually is, after locating the frozen section and uncovering the pipe, to build fires under it, by which process pipe is often burned and the iron much injured wherever the stoppage, instead of being continuous, consists of patches of ice, with empty spaces between them. Pipe which has been so heated several times, has its life pretty well exhausted. If the stave pipe should become stopped by freezing, it seems to present facilities for opening up a section by loosening the bands and removing the obstruction without damaging the pipe."

MR. HENNY.—"Mr. Vischer is right, I think. In Utah, we covered this pipe with two feet of dirt, and the cast iron we covered three and a half feet. So far we have not had any stoppages from freezing. I built a main line of 12-inch cast iron in South Dakota, and covered it seven feet. In the Northern Peninsula of Michigan we covered the pipes seven feet and over, and I heard after I left they had considerable trouble with freezing of the mains. In Denver the mains are covered about four feet; in Leadville, eight and one half feet."

MR. ALLARDT.—"There is a royalty on the pipe, is there not?"

A.—"Yes, but it is merely nominal. Mr. Allen, who had the patent, has given us the right for this part of California and for the Western States."

Q.—"In building a line of pipe, how much care do you have to take in laying it to exact grade before tightening the bands and filling the trench?"

A.—"The pipe is laid to the trench as graded, and the bands then tightened. We do not dig the trench wider than we can help, and we aim to have an equal space on each side of the pipe to work in."

PROF. KEITH.—"How about expansion?"

A.—"I have always laid this pipe in a trench, and have taken pains to have it back-filled immediately after construction, so that there would not be great changes in the temperature of the pipe. Where the pipe had been exposed I have never noticed any expansion. As regards expansion caused by saturation, the swelling of the wood lengthwise causes the butt joints to become perfectly tight."

Q.—"Have you ever had trouble from animals and rodents knawing the pipe in pursuit of water in a dry country?"

A.—"I have never known any trouble from this source."

PROF. CARNOT.—"It gives me extreme pleasure to be with you tonight. I am very glad to have had one opportunity during my trip through America of seeing some society of this kind, and the tone and scope of the discussion of its papers. I must say I have been very highly gratified. The subject is entirely a new one to me. It appears to have been handled in a very able and thorough manner, and there is much food for reflection. I would have liked, however, to have had a few more figures in regard to prices for comparison of its cost with that of other kinds of pipe.

As far as I am aware, we have no wooden pipes in Australia. Up to a few years ago we used cast-iron pipes, then an innovation came in the way of wrought iron, and that is now extensively used. During the past five or six years there is an entire cessation almost of the use of cast-iron pipes. In Melbourne we have works where machinery is used for manufacturing wrought-iron pipe, and it is turned out in large quantities. One point of interest to me, and one I have never been able to get any satisfactory information upon, namely, as to how far the lap of the plates and the heads of the rivets impede the flow of the water.

This timber pipe is quite a novelty to me, and the idea of making a large water main out of timber comes to me certainly in the light of a revelation. The question that suggests itself to my mind, of course, is how far is it applicable to the conditions that exist in Australia? We have a very small supply of pine wood; all our wood, as a rule, is very hard indeed, and intensely hard after it is seasoned. Here, as I understand, you have a pipe which is cheaper than either cast or wrought iron, which, as far as can be seen, is equally durable—at any rate, quite as durable as wrought iron—for I presume, the bands could be protected as well as the iron of wrought iron pipes could be protected. We are told, that as far as seen, when underground it is cleaner and smoother than cast-iron pipe, and, of course, much more so than the wrought iron. It certainly seems as if it were a great improvement, and was likely to be of very great value indeed. Knowing nothing about the subject practically, myself, I cannot add anything further, except to say that I feel very pleased indeed with the paper, and also with the discussion. It seems to me that it is a very marked advance in connection with water supply matters.

Of course the question of how it would do for sewerage is of still further interest. We are about to expend several millions of dollars

upon sewerage works in Melbourne. It would be interesting to know if pipe of this description would answer the purpose.

There is another pipe I would like to put in comparison with it, and that is the earthenware pipe. It is comparatively cheap ; it is very smooth and cleanly, but will not stand a very great pressure. We have used it to some extent for carrying water supplies, and with some success. But for sewerage purposes it is universally used. Perhaps the use of wooden pipe for sewerage purposes is a little remote.

I thank you for this opportunity of addressing the meeting ; I only regret that my departure for Australia on the steamer tomorrow will prevent my meeting with the members and becoming personally acquainted with them."

Q.—"Is not the use of earthenware pipe naturally a restricted one for water supplies, on account of the inability of the joints to withstand 'water hammer' ?"

PROF. CARNOT.—"Of course we only use it under circumstances where 'water hammer' can be guarded against. I have known, however, of earthenware pipe being used with success in conducting water for small towns, for instance where water has been taken from an aqueduct, a distance of several miles to a surface reservoir, metal pipes being used to conduct the water from the reservoir to the town."

MR. VISCHER.—"While not strictly pertinent to the subject of wooden pipe, I would like to ask if any member is able to express an opinion as to the relative merits of steel and wrought iron as regards durability. Perhaps Mr. Dickie has some data upon this subject ?"

MR. DICKIE.—"I think durability would be in favor of the iron ; it would depend, however, mainly upon the coating. When the coating is gone the life of the pipe is very short, as we all know in handling pipe.

I have listened very attentively to this subject tonight, but there is one thing I must say I cannot understand. In this wooden pipe it is not claimed that the wood presents any resistance to the pressure ; therefore it is no factor whatever in the strength of the pipe. If the wood is banded by steel, there must necessarily be as much steel in the bands as would make a steel pipe of the same strength. Now, steel formed into bands with a head on one end of the band and a nut on the other will certainly cost as much as manufactured steel pipe. Under these circumstances I do not see how the wooden

pipe can be made cheaper. I am talking about a pipe under pressure. The thickness of the metal is dependent upon the pressure it has to stand. Now I take it that the bands of a wooden pipe, under a head of 200 feet, would cost as much as a steel pipe carrying the same head. I think the cost of manufacturing steel into pipes in San Francisco is not more than seven eighths of a cent per pound, and that would be the amount that you would have for manufacturing the bands and making them ready for use in supporting the wooden pipe. The thread cut in the band takes out about the same amount as is taken out of a double-riveted iron pipe, so that the amount of material would be absolutely the same. I am not clear about the relative cost of pipe as represented by Mr. Henny's diagram; the difference, however, appears to me too much. As regards the steps shown in the diagram, when material is ordered for pipe at the mills, the increase of the thickness of the pipe is a very small factor. I know of instances where the variation in thickness of metal is very small indeed as pressure increases. I think this can be regulated as closely as the spaces between the bands of wooden pipe."

MR. HENNY.—"In answer to Prof. Carnot's remarks regarding exact figures as to the cost of this pipe, I can give list prices, quoted by the Excelsior Redwood Co. They are for pipe, banded every 12 inches and include cost of erection:

12 inches	80 cents	36 inches	$2.05	72 inches	$ 5.60
16 "	$1.00	42 "	2.35	84 "	7.25
20 "	1.30	48 "	2.65	96 "	9.60
24 "	1.50	54 "	4.35	108 "	10.80
30 "	1.75	60 "	4.80	120 "	13.10

Professor Carnot thinks that wooden pipe is about as durable as wrought iron pipe, but it appears to me reasonable to suppose that its life is much longer. As Mr. Dickie remarks, when the coating is gone the life of sheet iron pipe is very short. This holds good for those parts of the pipe where the coating has been knocked off, or is cracked, or is imperfect. For, under ordinary methods of pipe laying, who can guarantee absolutely perfect coating after the pipe is laid? Now the slightest imperfection in the coating leaves but from $\frac{1}{20}$ to $\frac{1}{12}$ of an inch of short-lived material to rust away, in order to have a leak. If one could keep sheet iron pipe tight, notwithstanding its rusting through in spots, until enough metal is worn away to make the pipe burst, then its life would approach that of wooden pipe. On the grade line, I agree with Professor Carnot that vitrified

sewer pipe is to be preferred to wood. But, I think, the largest size manufactured is 30 inch, and at that size it becomes very expensive. Then it must be kept to the exact grade line, as the cement joints cannot be depended upon under even slight pressure.

In comparing the diagrams of cost, Mr. Dickie appears to misunderstand me, as I do not claim that under high pressures wooden pipe is cheaper than sheet iron pipe. I believe to have called your attention this evening to the fact that no matter what material is used for the shell, the same amount of metal is required in either case to resist the bursting strain. What I attempted to show in the diagram is that, over and above this amount, there is required considerable metal in the case of sheet iron pipe under low pressure, simply to make the pipe stand up under outside pressures. It is under light heads that wooden pipe has the advantage of cost over sheet iron pipe, but it has the advantage of durability under all pressures."

MR. VISCHER.—"The longitudinal stiffness of the wooden lining should make the pipe self sustaining for certain lengths when carrying water, thus making it available for support on trestles if desirable. This may not often become necessary, yet I have known a case in the Sandwich Islands where this quality, if it exists to any extent, would have been highly in its favor. A swamp, with rock bottom, was overlaid by oozy, almost fluid mud, two to four feet deep. Trenches could not have been dug, and by far the simplest method would be to lay the whole pipe on low horses above the mud surface. Here all the material would have had to be packed on the men's backs for several miles, and the extreme lightness of the parts of which the stave pipe is built would have greatly recommended it. In fact, this quality should not be under rated, for lightness of parts is often more essential, where transportation is difficult, than lightness per foot of finished pipe."

REGULAR MEETING, MARCH 4th, 1892.

PROCEEDINGS.

MINUTES.

The meeting was called to order by the President, John Richards.

The minutes of the last regular meeting were read and approved.

The following new members, having been balloted for, were declared elected:

Conrad Eimbeck, Civil Engineer.....Guaymas, Mexico.
D. C. Henny, Civil Engineer.....San Francisco, Cal.
Alex. M. Reynolds, Civil Engineer.....Seattle, Wash.
Arthur H. Sanborn, Ass't City Surveyor.....San Francisco, Cal.

The following names were proposed for membership and referred to the Board of Directors:

Andrew Fraser, Mechanical Engineer, of San Francisco; proposed by John Richards, H. C. Behr and F. Orton.

Edward C. Jones, Civil Engineer, of San Francisco; proposed by Jos. B. Crockett, A. Schierholz and H. C. Tabrett.

Chas. D. Marx, Professor of Civil Engineering, Leland Stanford, Jr., University, Palo Alto; proposed by Horace B. Gale, Frank Soulé and C. E. Grunsky.

Leon H. Taylor, Civil Engineer, of Long Valley, Cal.; proposed by Wm. Minto, C. E. Grunsky and Otto von Geldern.

The Secretary read the following communication from the President:

A COMMUNICATION.

To the Technical Society of the Pacific Coast:

Having received the following communication from our distinguished Past President, Col. George H. Mendell, Engineer Corps, U. S. Army, I feel it incumbent on me to present it here with Colonel Mendell's consent, and in accordance with the suggestion it contains, to offer such personal explanation as the circumstances call for.

Colonel Mendell's communication is as follows:

"MR. JOHN RICHARDS,
President of the Technical Society, San Francisco, Cal.

SIR:—In the annual address to the Society of which you are President, read on January 15, 1892, the following remarks occur:

"'The improvement of rivers and harbors by the general government I think had better not be mentioned. So far as this Coast is concerned there seems no complaint, but on the Atlantic side the record is not one to call for commendation, when compared with the achievements of private enterprise.'"

My acquaintance with the improvements of rivers and harbors on the Pacific Coast permits me to say that there is no reason, relating to the works themselves, why they may not properly be mentioned and discussed. The engineers responsible for the works not only can have no objection, but would doubtless favor thorough discussion.

My acquaintance with works of this character on the East of the Rocky Mountains is less close. I know, however, many of the engineers who have now, or have had charge of these engineering works to be men of character and ability.

The opinion which you express, to the effect that these works are not worthy of commendation, is not the one generally held, and is, I am assured, a mistaken view. If it were otherwise, the direction of these works would long since have passed into other hands. But you appear to have reached your conclusion after study, implied by your references to a record.

You may be in possession of information not generally known. The subject is one of general interest, and of great importance. The reputation of a worthy class of men is assailed by your statement.

You will therefore doubtless perceive the propriety, upon request now made, of laying before the Technical Society, or otherwise making public, the facts which, in your opinion, justify the disparaging assertions and implications contained in the quoted statement.

Very respectfully,

(Signed.) G. W. MENDELL."

In respect to this communication, and the subject incidentally referred to in the address, the works in question are matters of national and general concern, and involve features quite distinct from and independent of the ability of the Engineer Corps, which it was not the intention to call in question at the time of writing the sentence quoted from the annual address.

The words used hardly call for this disclaimer of any intention to reflect upon the personelle or qualifications of the Engineer Corps. If so, full apology is now made, but as before said, the works are of public concern, subject not only to the criticism common to all such undertakings, but in greater degree, because executed outside of what may be called the profession in general.

My impression cannot therefore be considered as carrying other weight than that of personal opinion, and as such, liable to error; especially as in this case the subject pertains to a branch of engineering work with which I am not familiar.

There was in the use of that term "record," no intention of declaring information, except in a limited degree, other than is open to everyone in the technical and secular literature of the time; in this sense the term record was employed.

It must be admitted, even by the Engineer Corps and their friends, that serious criticisms of many of the river and harbor works on the Atlantic side of the country have appeared recently in journals of good, or even high standing, and at times over the signature of civil engineers of wide repute.

I do not think it necessary or expedient to cite references generally accessible in current technical literature, or to seek support for my statement in such expressions as those contained in a recent report to the St. Paul Chamber of Commerce by a committee of theirs, on the works carried out on the Upper Mississippi River.

Such presentations here would perhaps lead to a spirit of controversy, undesirable and unnecessary if Colonel Mendell will admit that such published matter was sufficient to call out the expression used in respect to government engineering works on the Atlantic side of the country, especially as at the time of writing no reply had been made to some of the most serious of the charges presented.

I think it due to Colonel Mendell to say that since receiving his communication, some inquiry among the profession here develops the fact that his own administration on the Pacific Coast has not only escaped criticism among the profession generally, but earned both approbation and admiration.

As even errors and mistakes can have a useful side, so it may be in this case, if the criticisms of public works will bring to the notice of this Society, the points in controversy between the private and government engineers in the East, especially if such consideration will induce Colonel Mendell and his staff to lay before the Society information respecting works under his administration, which will have an especial interest to the members.

February 22d, 1892.

Since the preparation of the foregoing communication I have received from Colonel George H. Mendell documentary evidence of both a public and private nature, showing beyond mistake that not only have the works in the upper Mississippi been beneficial, but that such works have met with commendation from all but a few sources among those interested.

The papers submitted by Colonel Mendell are:

(1) A communication from Major A. Mackenzie, in charge of the Government work on the Upper Mississippi River.

(2) Communications to Major Mackenzie from some of the principal steamboat lines, accompanied in some cases by records and dates of a character to show an improvement of the channels, and commendatory of the works carried out under the Corps.

(3) Private letters by shipping firms, asserting that the works under Major Mackenzie's administration, have been of great benefit to the interests of navigation.

(4) A communication from C. C. Andrews, Chairman of the Committee on the Mississippi River, St. Paul Chamber of Commerce, stating that the resolution passed by the chamber on Dec. 10th, 1888 was a mistake in so far as being a concensus of opinion in that body, having been withdrawn or rescinded by a subsequent resolution passed on the 17th of December succeeding; also saying, that the Government Engineer Officers enjoy fully the confidence of that Chamber.

(5) Quotations from the Editorial Columns of the "St. Paul *Pioneer Press*," of Dec. 12th, 1888, condemning and denying the allegations set up in the resolution passed by the Chamber of Commerce on Dec. 10th, 1888.

The copious nature of the public portion of these various documents prevents them being presented here, and it is not necessary, as

Colonel Mendell indicates, further than to, on my part, concede the error of the statement at first quoted from my annual address.

My information respecting the Government engineering works on the upper Mississippi was mainly of an *ex parte* nature, derived from private sources and from newspaper clippings with dates removed, but left to inference as being current.

I think that the substance of these remarks, spread upon the minutes of the Society, will very fully eliminate any effect produced by the remarks in the annual address.

As the editor of a publication dealing to some extent with engineering matters, perhaps my opportunities for observing the untruth and unreliability of floating news is greater than most members of the Society, and I take this occasion to say that the untrue and inexact part is the main one.

San Francisco, March 4, 1892. J. RICHARDS.

Dr. R. Heidrich then addressed the members on the subject of Mnemonics, and its usefulness in mentally retaining data and formulæ. Examples were given to show the simplicity of impressing the mind with a subject, connecting this with any other fixed in the mind, and calling up that subject, thereby, at any time. Dr. Heidrich had committed to memory the first fifty logarithms to seven places of decimals, and repeated them at the pleasure of the members to any desired natural number.

The interesting subject was discussed, after which a vote of thanks was passed for the author. (The paper will be published in a subsequent bulletin.)

The Nicaragua Canal Committee having been requested to make a report in the near future, the Chairman of that committee announced that one would be submitted at the next regular meeting.

Adjourned. OTTO VON GELDERN, *Secretary.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME IX. No. 3.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

THE SICKLE OR PERFECT RAILWAY CURVE.

BY D. E. HUGHES, C. E. Mem. Tech. Soc.

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[Presented April 1st, 1892.]

INTRODUCTION.

In railway location it is desirable that circular arcs be not connected direct to tangents, but eased off by a line of diminishing curvature. This is done now in several different ways.

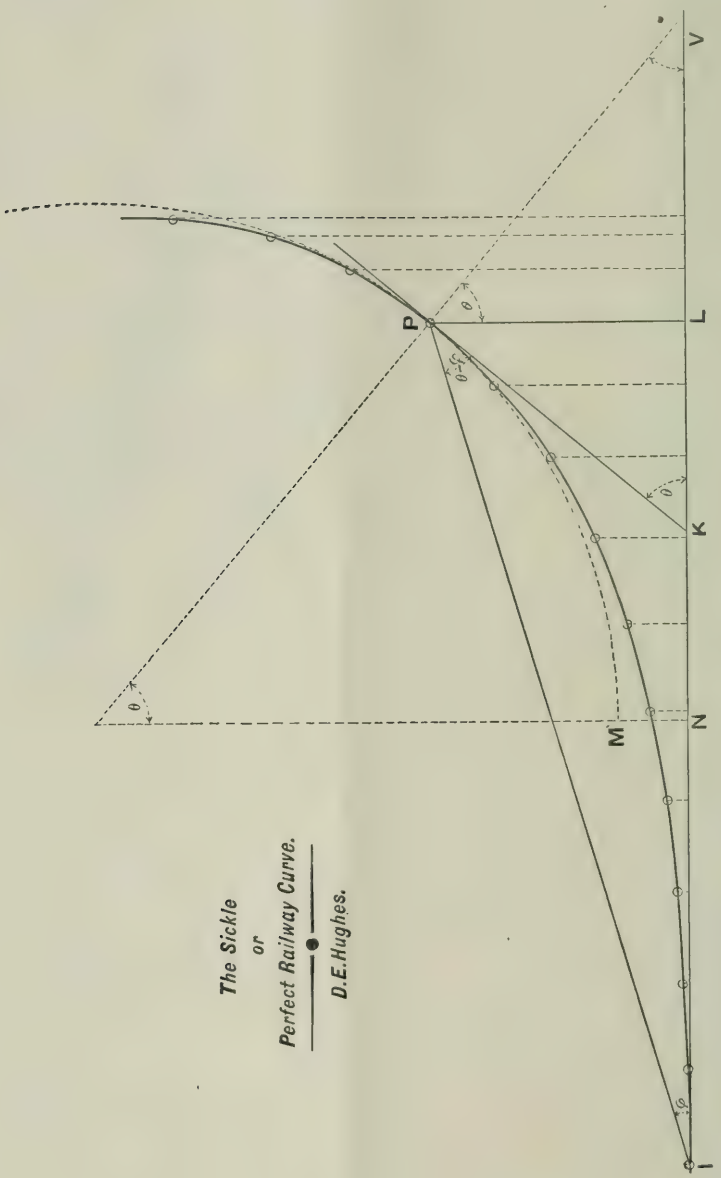
Some make the transition by compounding circular arcs of finite length, thus removing part of the evil and permitting the remainder to be met on the installment plan.

Others make the change by means of the cubic parabola of which a short length of small total curvature very nearly coincides with the perfect transition curve.

Still others make the "easement" by some indefinable, indescribable thing that is not a curve at all in a mathematical sense, not conforming throughout its length to any one law, and incapable of being extended beyond narrow limits.

Very rough locations are by some called "good enough" on the grounds that track-layers do not follow exactly any given location: but, other things being equal, is it not better that these unavoidable deviations be from the perfect curve?

Some too, make overmuch of saving a few minutes' time in calculating, forgetting how small need be the advantage of a better


V
L
K
N
M
I
P
θ
θ
θ
θ
90°-θ
The Sickle
or
Perfect Railway Curve.
D.E.Hughes.

curve on a good road with heavy traffic, to soon repay the extra cost. This is not a criticism on approximate methods in general. Any easement is better than none at all, and several of the curves in use are very good within the limits intended for them. But it would be better to have uniformity of practice. Men could work together to better advantage, and time would be saved in school if but one transition curve was in use.

The curve adopted should be the most perfect practicable, to meet the high precision that all field work is rapidly approaching. It should be determined independently of any other curve so that a line containing it can be described as definitely and briefly as can one composed of only tangents and circles.

The curve required has been defined by several. For a correct idea of it, conceive a curve compounded of infinitesimal circular arcs of uniformly varying curvature. Evidently this curve if begun with an infinite radius, has at any point a curvature directly proportional to its length, hence the superelevation of the outer rail may begin with the curve and, but for the excess of gauge of track over its horizontal projection, increase uniformly. If this excess is considered then the tangent, not the sine of the lateral slope must increase uniformly. Luckily the track can be laid in conformity with the latter plan with the same facility, and to meet the fast trains of the future, it may be done.

The following pages contain the curve described above, the principal equations relating to it, and its more important functions tabulated. The tables contain more decimal places than would usually be necessary in practice, but they have been retained that interpolation may be more accurately effected, and in order that finer discrepancies between this curve and those in use may appear. To obtain a working knowledge of these equations and tables in the least time would require that they be illustrated with solutions of many of the different problems likely to occur in practice, but so much detail would encumber this paper too much, hence only the skeleton with brief explanations, is submitted.

The table has been extended to 90 degrees in order that great lengths of this spiral may be located, for it is often the case that it fits the ground better and is easier to locate than a compound curve composed of several circular arcs connected by "easement" curves.

A location can be made by means of this curve without using circular arcs at all, hence it should not receive a name that would seem to limit its application—should not be called "transition

curve." In this paper it is called *sickle*, suggested by the resemblance of the first 90 or 100 degrees of it to the old reaper's sickle.

DEFINITION.

The "sickle" is a plane curve whose radius of curvature varies inversely as its length measured from its initial point.

EQUATIONS DEDUCED.

In Figure 1 let the origin of coördinates be I, the initial point of the curve, and P any point on the curve. $x =$ I L. $y =$ P L. R = radius of curve at P. $c =$ chord I P. $s =$ length of curve I P. $t =$ tangent I V. $f =$ offset M N. $\theta =$ total curvature of arc I P. $\phi =$ deflection angle of point P. X, Y, C, F, and T represent those functions of θ displaced by them in the equations where they first appear.

From the definition, $R = \frac{k}{s}$ (a) where k is a constant, but

$R = \frac{ds}{d\theta}$ the general formula for radius of curvature.

Therefore, $\frac{ds}{d\theta} = \frac{k}{s}$

Integrating and reducing, $s = \sqrt{2k\theta}$, (b) the intrinsic equation of the curve.

From (a) and (b) $s = 2R\theta$ (1), or twice the circular arc MP.

From (b) $\theta \propto s^2$ (2)

TO TRANSFORM TO RECTANGULAR COÖRDINATES.

$$\left.\begin{aligned} dx &= ds \cos.\ \theta \\ dy &= ds \sin.\ \theta \end{aligned}\right\}$$ General formulæ of transformation.

Differentiating (b), $ds = \sqrt{\frac{k}{2\theta}}\, d\theta$

Substituting,

$$\left\{\begin{aligned} dx &= \sqrt{\frac{k}{2\theta}} \cos.\ \theta\, d\theta \\ dy &= \sqrt{\frac{k}{2\theta}} \sin.\ \theta\, d\theta \end{aligned}\right\}$$

Integrating :

$$x = s\left(1 - \frac{\theta^2}{5.2!} + \frac{\theta^4}{9.4!} - \frac{\theta^6}{13.6!^*} + \ldots\right) \text{ or } x = s\,\mathrm{X} \quad (3)$$

$$y = s\left(\frac{\theta}{3.1!} - \frac{\theta^3}{7.3!} + \frac{\theta^5}{11.5!} - \frac{\theta^7}{15.7!} + \ldots\right) \text{ or } y = s\,\mathrm{Y} \quad (4)$$

In right triangle I P L :

$$\phi = \tan^{-1}\frac{y}{x} = \tan^{-1}\frac{\mathrm{Y}}{\mathrm{X}} = \frac{\theta}{3} - \frac{8\theta^3}{2835} - \frac{32\theta^5}{467775} \cdot \ldots \quad (5)$$

$$c = \frac{y}{\sin.\,\phi} = \frac{s\mathrm{Y}}{\sin.\,\phi} \text{ or } c = s\,\mathrm{C} \quad (6)$$

$$f = s\,\mathrm{Y} - \mathrm{R}\ \text{vers.}\ \theta = \mathrm{R}\ (2\theta\mathrm{Y} - \text{vers.}\ \theta) \text{ or } f = \mathrm{R\,F} \quad (7)$$

developing F, $f = \mathrm{R}\left(\frac{\theta^2}{6} - \frac{\theta^4}{168} + \frac{\theta^6}{7920} - \frac{\theta^8}{604800} + \right)$ (8)

$t = \mathrm{I\,L} + \mathrm{L\,V} = s\,\mathrm{X} + s\,\mathrm{Y}\ \tan.\,\theta = \mathrm{R}\ (2\theta\mathrm{X} + 2\theta\mathrm{Y}\ \tan.\,\theta)$ or $t = \mathrm{R\,T}$ (9)

Area between chord I P and curve =

$$s^2\left(\frac{\theta}{12} + \frac{\theta^3}{105} + \frac{4\theta^5}{31185} + \ldots\right) \quad (10)$$

TO LOCATE THE CURVE.

Suppose a length s, of 10 stations, and total curvature $\theta = 50°$. From eq. (2) the direction of the curve at the several stations; that is, the several values of θ are as the squares of 1, 2, 3 . . . . 10. Since the last is 50°, the first is $\frac{50°}{10^2} = \frac{1}{2}$, and the others 4, 9, 16, etc., times this, or

$\frac{1}{2}°$, 2°, $4\frac{1}{2}°$, 8°, $12\frac{1}{2}°$, 18°, $24\frac{1}{2}°$, 32°, $40\frac{1}{2}°$, 50°.

TO LOCATE THE STATIONS BY OFFSETS FROM TANGENT.

With argument $\frac{1}{2}°$, 2°, $4\frac{1}{2}°$, etc., take from X and Y columns the corresponding decimals multiplying them, as per (3) and (4), by 1, 2, 3, etc., times a station length respectively. The results are the

*13.6! means 13 times 6 X 5 X 4 X 3 X 2 X 1.

abscissæ and ordinates of the stations, and for stations of 100 feet are as follows:

STA.	θ	x	y	STA.	θ	x	y
1	$\frac{1}{2}°$	99.999	0.291	6	18°	594.105	62.390
2	2°	199.976	2.327	7	$24\frac{1}{2}°$	687.308	98.480
3	$4\frac{1}{2}°$	299.815	7.851	8	32°	775.404	145.650
4	8°	399.221	18.591	9	$40\frac{1}{2}°$	856.060	204.609
5	$12\frac{1}{2}°$	497.627	36.238	10	50°	926.484	275.443

TO LOCATE THE SAME POINTS BY LONG CHORDS AND DEFLECTION ANGLES.

Use same argument as before and obtain values of ϕ and C multiplying latter, as per eq. (6), by 100, 200, 300, etc., respectively. The results are the deflection angles and long chords from I to the other stations, and are as follows:

STA.	ϕ	C	STA.	ϕ	C
1	0° 10′ 00″	100.000	6	5° 59′ 42″	597.372
2	0° 40′ 00″	199.989	7	8° 09′ 14″	694.328
3	1° 30′ 00″	299.918	8	10° 38′ 18″	788.964
4	2° 39′ 58″	399.654	9	13° 26′ 32″	880.172
5	4° 09′ 54″	498.943	10	16° 33′ 26″	966.562

The deflection angles may be used and each point located by measurement from the last preceding one. This measurement, however, must not be 100 feet, for in this work a station length is measured *on the curve.*

The error made, if this point is disregarded, is very small at first, but it is cumulative, and it will throw the curve outside of the one aimed at and make it longer—a very good curve still, but the traverse in the field will not agree with that in the office.

To find radius of curvature at any station, use eq. (1), where $R = \frac{s}{2\theta}$. In this particular case, at station 8, for instance,

$$R = \frac{8 \times 100}{2 \times .5585} = 716.20.$$

The decimal in the denominator is the value of 32° in circular measure, and is found with it in the first column of the table.

An equivalent result is more quickly obtained by noting that 8 stations consume, in this case, 32°, an average of 4°, and as curvature at start is 0, and increases in arithmetical progression, the degree of curve at close is twice the average, or 8°.

In present practice it is often the problem to locate the curve, having given the degree or radius of circular arc and offset M N. The relation between the given quantities and θ is expressed in (7) or (8), and the function of θ therein is tabulated in column headed "F."

Suppose radius of circular arc = 572.96 — and offset M N = 70. 78 — . 70.78 ÷ 572.96 — = .1235 +. With this as argument in column "F" take from first column the corresponding θ, which is 50°, or .87266. Now by eq. (1) $s = 2 \times 572.96 \times .87266 = 1000$ feet. Take from the same place in the table $\phi = 16° 33' 26''$, and 1000 times C 966.56. Now having chord P I, and angle I P K 50° — 16° 33′ 26″, locate I, and then the curve.

TO FIND LENGTH OF TANGENT IV WHEN ONLY SICKLES ARE USED.

Suppose external angle at V 100°, and that two equal sickles are to be used, making the sharpest curvature at vertex 10 degrees. $\theta = 100° \div 2 = 50°$. Take from table X Y, and circular value of θ corresponding to 50°, then substitute these, tangent 50°, and radius of 10° curve in eq. (9), to obtain t. The quantity in parenthesis in eq. (9) is tabulated, (as yet only to 30°) and appears in the last column T. If a circular arc of a given radius is to intervene, let θ be angle consumed by each sickle. The circular arc must consume the rest of the exterior angle $\triangle$ (not shown in Fig. 1), or $\triangle - 2\theta$, and tangent can be found from the following equation, not previously given:

$$t = R \left([1 + F] \tan. \tfrac{1}{2} \triangle - \sin. \theta + 2\theta X \right)$$

The foregoing examples are purposely simple and few in number, the intention being only to illustrate the equations and show what

the tables contain. Concerning additional and more complicated problems that may arise, suffice it to say, that, since the sickle is a mathematical curve, they can all be solved. Passing obstructions, etc., can all be readily done with a little more work in calculating, however, than is required with the circle.

TO DRAW THE CURVE.

The equations show that *all sickles are similar*, hence to draw any arc of the curve all that is required is one well-constructed sickle and a pantograph. The pattern should be on material that will preserve its *form*.

Further, some scale should be *assumed* for it, and points where, according to this scale, the radius of curvature agrees with the radii of 2, 3, 4, etc., degree curves should be marked and portions of such radii drawn, so that the plate can be more quickly adjusted relatively to the map, and so that just such portion of the pattern may be used as will reproduce on the map the arc required, and no more.

The pantograph and pattern are mentioned only as a *complete* solution — as a plan to draw the sickle to any scale. Perhaps the draughtsman would be better suited by having several patterns without the pantograph—patterns conforming to the scales of his drawings and to be used as rulers.

These sickle rulers to be most handy should be marked with radii, etc., as described above. Again, transparent paper may be used with the required sickles, markings, and all, printed thereon, and the curve traced; or the paper may be used to prick the important points, and the corresponding ruler to draw the line. Sickles, being similar, may, like circles, be denominated as "20 minute," "3 degree," etc., a "40′ sickle" meaning one in which the *first 100 feet* of it curves 40 minutes; that is, one in which the degree of curve at the beginning is 0, at the middle, 40′, and at the end of the 100 feet, 1°, 20′.

APPROXIMATIONS.

When θ is small, eq. (5) shows that $\phi = \frac{1}{3}\theta$ *approximately*. Referring to the table, it is seen that not until θ reaches about 21° 20′ is the error so much as 30″. In eq. (4) when θ is small, $y = s\frac{\theta}{3}$ *nearly*, and combining this with (2) gives $y \propto s^3$ *approximately*. These two equations, deduced in a different manner, however, give the curves of a recent writer. Since, as seen in (3), s exceeds x but little when θ is small, an approximation to the

above approximation is $y \propto x^3$, the cubic parabola, used now by several.

By rejecting all of the series after the first term in (8), and combining with one, there results $s = \sqrt{24\,R} \times$ offset, a property of the first good "curve of adjustment" ever used.

A fair approximation to any of these is the "elastic curve," which, with considerable trouble, may be drawn with an elastic ruler.

SAMPLE OF NOTES.

NO OF STATION.	KIND OF LINE.	BEARING AT FAR END	DISTANCE.
23	Tangent	N 40° E	400 feet
27	Sickle	N 46° E	300 "
30	Circle	N 66° E	500 "
35	Sickle	N 80° E	400 "
39	Circle	S 79° E	700 "
46	Sickle	S 67° E	300 "
49	Sickle	S 53° E	400 "
53	Sickle	S 50° E	300 "
56	Tangent		

EXPLANATION.

The sickle beginning at station 27 turns through 6° in a length of 300 feet, or an average of 2° per 100 feet. As it begins with 0 curvature, it ends a 4° curve, hence, what follows must begin with that. The next is a circular arc of 20° total curvature, and being 5 chains long is a 4° curve as required. Next a sickle 4 chains long through 14°, average curve 3½°, beginning as a 4°, therefore ending as a 3° curve. Next a 3° circle. Next a sickle of 12°, 3 chains long, beginning 3°, average 4°, ending 5°. Next a sickle of 14°, and 4 chains, average a 3½° curve, beginning 5°, hence ending 2°. Next a 3 chain sickle turning through 3°, an average of 1 degree per chain, beginning a 2° curve, and ending *straight* in a direction S 50 E.

It is evident that some arc of any sickle will unite with any arc of a given sickle without causing a *finite* change where the arcs join. By thus compounding, any direction required at the extremity can be attained even without altering the total length.

A simple sickle can be made to pass through any three points.

A compounded sickle will go anywhere.

θ	X		Y		ϕ	C	F		T
.0000000 10′	One		.000000		0° 00′ 00″	One	.000000		.000000
		1		970				1	5818
.0029089 10′	.999999		.000970		0° 03′ 20″	One	.000001		.005818
		3		970			1	5	5818
.0058178 20′	.999996		.001940		0° 06′ 40″	.999999	.000006		.011636
		4		969			3	7	5818
.0087266 30′	.999992		.002909		0° 10′ 00″	.999996	.000013		.017454
		6		970			3	10	5818
.0116355 40′	.999986		.003879		0° 13′ 20″	.999993	.000023		.023272
		7		970			3	13	5818
.0145444 50′	.999979		.004849		0° 16′ 40″	.999990	.000036		.029090
	———	9	———	969		———	4	15	———5819
.0174533 1°	.999970		.005818		0° 20′ 00″	.999986	.000051		.034909
	———	11	———	970		———	5	18	———5819
.0203622 10′	.999959		.006788		0° 23′ 20″	.999981	.000069		.040728
		13		969			5	21	5820
.0232711 20′	.999946		.007757		0° 26′ 40″	.999976	.000090		.046548
		14		969			6	24	5820
.0261799 30′	.999932		.008726		0° 30′ 00″	.999970	.000114		.052368
		16		970			7	27	5821
.0290888 40′	.999916		.009696		0° 33′ 20″	.999963	.000141		.058189
		18		970			8	30	5822
.0319977 50′	.999898		.010666		0° 36′ 40″	.999955	.000171		.064011
	———	20	———	969		———	9	32	———5822
.0349066 2°	.999878		.011635		0° 40′ 00″	.999946	.000203		.069833
	———	21	———	969		———	10	35	———5823
.0378155 10′	.999857		.012604		0° 43′ 20″	.999936	.000238		.075656
		23		969			10	38	5824
.0407244 20′	.999834		.013573		0° 46′ 40″	.999926	.000276		.081480
		24		969			11	41	5825
.0436332 30′	.999810		.014542		0° 50′ 00″	.999915	.000317		.087305
		26		970			12	44	5826
.0465421 40′	.999784		.015512		0° 53′ 20″	.999903	.000361		.093131
		28		969			12	47	5827
.0494510 50′	.999756		.016481		0° 56′ 40″	.999891	.000408		.098958
	———	30	———	969		———	13	49	———5829
.0523599 3°	.999726		.017450		1° 00′ 00″	.999878	.000457		.104787
	———	31	———	969		———	14	52	———5830
.0552688 10′	.999695		.018419		1° 03′ 20″	.999864	.000509		.110617
		33		969			15	55	5831
.0581777 20′	.999662		.019388		1° 06′ 40″	.999849	.000564		.116448
		35		969			15	58	5832
.0610865 30′	.999627		.020357		1° 10′ 00″	.999834	.000622		.122280
		36		969			16	61	5834
.0639954 40′	.999591		.021326		1° 13′ 20″	.999818	.000683		.128114
		38		969			17	63	5835
.0669043 50′	.999553		.022295		1° 16′ 40″	.999801	.000746		.133949
	———	40	———	968		———	18	66	———5836
.0698132 4°	.999513		.023263		1° 20′ 00″	.999783	.000812		.139785
	———	42	———	969		———	18	69	———5838
.0727221 10′	.999471		.024232		1° 23′ 20″	.999765	.000881		.145623
		43		969			19	72	5840
.0756310 20′	.999428		.025201		1° 26′ 40″	.999746	.000953		.151463
		45		968			20	75	5843
.0785398 30′	.999383		.026169		1° 30′ 00″	.999726	.001028		.157306
		46		968			21	78	5844
.0814487 40′	.999337		.027137		1° 33′ 20″	.999705	.001106		.163150
		48		968			21	80	5846
.0843576 50′	.999289		.028105		1° 36′ 40″	.999684	.001186		.168996
	———	50	———	968		———	22	83	———5848
.0872665 5°	.999239		.029073		1° 40′ 00″	.999662	.001269		.174844

θ	X		Y		ϕ	C		F		T	
.0872665 5′	.999239		.029073		1° 40′ 00″	.999662		.001269		.174844	
		52		968			23		86		5850
.0901754 10′	.999187		.030041		1° 43′ 20″	.999639		.001355		.180694	
		53		968			24		89		5852
.0930843 20′	.999134		.031009		1° 46′ 40″	.999615		.001444		.186546	
		55		968			24		91		5855
.0959931 30′	.999079		.031977		1° 50′ 00″	.999591		.001535		.192401	
		57		968			25		94		5857
.0989020 40′	.999022		.032945		1° 53′ 20″	.999566		.001629		.198258	
		58		967			26		97		5859
.1018109 50′	.998964		.033912		1° 56′ 40″	.999540		.001726		.204117	
		60		967			27		101		5861
.1047198 6°	.998904		.034879		1° 59′ 59″	.999513		.001827		.209978	
		62		968			28		103		5864
.1076287 10′	.998842		.035847		2° 03′ 19″	.999485		.001930		.215842	
		63		967			28		106		5867
.1105376 20′	.998779		.036814		2° 06′ 39″	.999457		.002036		.221709	
		65		967			29		108		5869
.1134464 30′	.998714		.037781		2° 09′ 59″	.999428		.002144		.227578	
		67		967			30		111		5872
.1163553 40′	.998647		.038748		2° 13′ 19″	.999398		.002255		.233450	
		69		967			30		114		5875
.1192642 50′	.998578		.039715		2° 16′ 39″	.999368		.002369		.239325	
		70		966			31		117		5877
.1221730 7°	.998508		.040681		2° 19′ 59″	.999337		.002486		.245202	
		72		967			32		120		5880
.1250819 10′	.998436		.041648		2° 23′ 19″	.999305		.002606		.251082	
		73		966			33		123		5884
.1279908 20′	.998363		.042614		2° 26′ 39″	.999272		.002729		.256966	
		75		966			33		125		5887
.1308996 30′	998288		.043580		2° 29′ 59″	.999239		.002854		.262853	
		77		966			34		128		5890
.1338085 40′	.998211		.044546		2° 33′ 19″	.999205		.002982		.268743	
		79		966			35		131		5893
.1367174 50′	.998132		.045512		2° 36′ 39″	.999170		.003113		.274636	
		80		965			36		134		5897
.1396263 8°	.998052		.046477		2° 39′ 58″	.999134		.003247		.280533	
		82		966			37		137		5900
.1425352 10′	.997970		.047443		2° 43′ 18″	.999097		.003384		.286433	
		84		965			38		139		5903
.1454441 20′	.997886		.048408		2° 46′ 38″	.999060		.003523		.292336	
		85		965			38		142		5907
.1483529 30′	.997801		.049373		2° 49′ 58″	.999022		.003665		.298243	
		87		965			39		145		5911
.1512618 40′	.997714		.050338		2° 53′ 18″	.998983		.003810		.304154	
		89		965			39		148		5914
.1541707 50′	.997625		.051303		2° 56′ 38″	.998944		.003958		.310068	
		90		965			40		151		5918
.1570796 9°	.997535		.052268		2° 59′ 58″	.998904		.004109		.315986	
		92		964			41		153		5922
.1599885 10′	.997443		.053232		3° 03′ 18″	.998863		.004262		.321908	
		94		964			42		156		5926
.1628974 20′	.997349		.054196		3° 06′ 38″	.998821		.004418		.327834	
		95		964			42		159		5929
.1658062 30′	.997254		.055160		3° 09′ 57″	.998779		.004577		.333763	
		97		964			43		162		5934
.1687151 40′	.997157		.056124		3° 13′ 17″	.998736		.004739		.339697	
		99		964			44		165		5938
.1716240 50′	.997058		.057088		3° 16′ 37″	.998692		.004904		.345635	
		100		963			45		167		5942
.1745329 10°	.996958		.058051		3° 19′ 57″	.998647		.005071		.351577	

θ	X	Y	ϕ	C	F	T
.1745329 10°	.996958	.058051	3° 19′ 57″	.998647	.005071	.351577
	102	963			46	170 5947
.1774418 10′	.996856	.059014	3° 23′ 17″	.998601	.005241	.357524
	104	963			46	173 5951
.1803507 20′	.996752	.059977	3° 26′ 37″	.998555	.005414	.363475
	105	963			47	177 5955
.1832595 30′	.996647	.060940	3° 29′ 56″	.998508	.005591	.369430
	107	963			48	179 5960
.1861684 40′	.996540	.061903	3° 33′ 16″	.998460	.005770	.375390
	109	962			48	182 5964
.1890773 50′	.996431	.062865	3° 36′ 36″	.998412	.005952	.381354
	111	962			49	184 5969
.1919862 11°	.996320	.063827	3° 39′ 56″	.998363	.006135	.387323
	112	962			50	187 5974
.1948951 10′	.996208	.064789	3° 43′ 16″	.998313	.006322	.393297
	114	962			51	190 5979
.1978040 20′	.996094	.065751	3° 46′ 36″	.978262	.006512	.399276
	115	961			51	193 5984
.2007128 30′	.995979	.066712	3° 49′ 55″	.998211	.006705	.405260
	117	961			52	195 5989
.2036217 40′	.995862	.067673	3° 53′ 15″	.998159	.006900	.411249
	119	961			53	198 5994
.2065306 50′	.995743	.068634	3° 56′ 35″	.998106	.007098	.417243
	121	961			54	201 5999
.2094395 12°	.995622	.069595	3° 59′ 55′	.998052	.007299	.423242
	122	960			55	204 6004
.2123484 10′	.995500	.070555	4° 03′ 15″	.997997	.007503	.429246
	124	960			55	207 6010
.2152573 20′	.995376	.071515	4° 06′ 35″	.997942	.007710	.435256
	125	960			56	209 6015
.2181661 30′	.995251	.072475	4° 09′ 54″	.997886	.007919	.441271
	127	960			57	212 6020
.2210750 40′	.995124	.073435	4° 13′ 14″	.997829	.008131	.447291
	129	959			57	215 6026
.2239839 50′	.994995	.074394	4° 16′ 34″	.997772	.008346	.453317
	131	959			58	218 6032
.2268928 13°	.994864	.075353	4° 19′ 53″	.997714	.008564	.459349
	132	959			59	221 6038
.2298017 10′	.994732	.076312	4° 23′ 13″	.997655	.008785	.465387
	134	959			60	223 6044
.2327106 20′	.994598	.077271	4° 26′ 33″	.997595	.009008	.471431
	135	958			60	226 6049
.2356194 30′	.994463	.078229	4° 29′ 52″	.997535	.009234	.477480
	137	958			61	229 6055
.2385283 40′	.994326	.079187	4° 33′ 12″	.997474	.009463	.483535
	139	958			62	232 6062
.2414372 50′	.994187	.080145	4° 36′ 32″	.997412	.009695	.489597
	141	957			63	235 6068
.2443461 14°	.994046	.081102	4° 39′ 52″	.997349	.009930	.495665
	142	957			64	237 6074
.2472550 10′	.993904	.082059	4° 43′ 12″	.997285	.010167	.501739
	144	957			64	240 6080
.2501639 20′	.993760	.083016	4° 46′ 32″	.997221	.010407	.507819
	146	957			65	243 6086
.2530727 30′	.993614	.083973	4° 49′ 51″	.997156	.010650	.513905
	147	956			66	246 6093
.2559816 40′	.993467	.084929	4° 53′ 11″	.997090	.010896	.519998
	149	956			66	248 6100
.2588905 50′	.993318	.085885	4° 56′ 31″	.997024	.011144	.526098
	150	955			67	251 6107
.2617994 15°	.993168	.086840	4° 59′ 50″	.996957	.011395	.532205

θ	X	Y	ϕ	C	F	T
.2617994 15°	.993168	.086840	4° 59′ 50″	.996957	.011395	.532205
	152	955			68 254	6114
.2647083 10′	.993016	.087795	5° 03′ 10″	.996889	.011649	.538319
	154	955			69 257	6120
.2676172 20′	.992862	.088750	5° 06′ 30″	.996820	.011906	.544439
	156	955			69 260	6127
.2705260 30′	.992706	.089705	5° 09′ 49″	.996751	.012166	.550566
	157	954			70 262	6134
.2734349 40′	.992549	.090659	5° 13′ 09″	.996681	.012428	.556700
	159	954			71 265	6141
.2763438 50′	.992390	.091613	5° 16′ 28″	.996610	.012693	.562841
	160	954			72 268	6149
.2792527 16°	.992230	.092567	5° 19′ 47″	.996538	.012961	.568990
	162	953			72 271	6156
.2821616 10′	.992068	.093520	5° 23′ 07″	.996466	.013232	.575146
	164	953			73 273	6164
.2850705 20′	.991904	.094473	5° 26′ 27″	.996393	.013505	.581310
	165	953			74 276	6171
.2879793 30′	.991739	.095426	5° 29′ 46″	.996319	.013781	.587481
	167	952			75 279	6179
.2908882 40′	.991572	.096378	5° 33′ 06″	.996244	.014060	.593660
	169	952			75 282	6186
.2937971 50′	.991403	.097330	5° 36′ 25″	.996169	.014342	.599846
	171	952			76 284	6194
.2967060 17°	.991232	.098282	5° 39′ 45″	.996093	.014626	.606040
	172	951			77 287	6202
.2996149 10′	.991060	.099233	5° 43′ 05″	.996016	.014913	.612242
	174	951			78 290	6210
.3025238 20′	.990886	.100184	5° 46′ 24″	.995938	.015203	.618452
	175	950			78 293	6218
.3054326 30′	.990711	.101134	5° 49′ 43″	.995860	.015496	.624670
	177	950			79 296	6226
.3083415 40′	.990534	.102084	5° 53′ 03″	.995781	.015792	.630896
	179	950			80 299	6235
.3112504 50′	.990355	.103034	5° 56′ 22″	.995701	.016091	.637131
	180	950			81 301	6243
.3141593 18°	.990175	.103984	5° 59′ 42″	.995620	.016392	.643374
	182	949			81 304	6252
.3170682 10′	.989993	.104933	6° 03′ 02″	.995539	.016696	.649626
	183	949			82 306	6260
.3199771 20′	.989810	.105882	6° 06′ 21″	.995457	.017002	.655886
	185	948			83 309	6269
.3228859 30′	.989625	.106830	6° 09′ 40″	.995374	.017311	.662155
	187	948			84 312	6278
.3257948 40′	.989438	.107778	6° 13′ 00″	.995290	.017623	.668433
	189	947			84 315	6287
.3287037 50′	.989249	.108725	6° 16′ 20″	.995206	.017938	.674720
	190	947			85 318	6295
.3316126 19°	.989059	.109672	6° 19′ 39″	.995121	.018256	.681015
	192	947			86 321	6304
.3345215 10′	.988867	.110619	6° 22′ 59″	.995035	.018577	.687319
	193	946			87 323	6314
.3374304 20′	.988674	.111565	6° 26′ 18″	.994948	.018900	.693633
	195	946			87 326	6323
.3403392 30′	.988479	.112511	6° 29′ 37″	.994861	.019226	.699956
	197	946			88 329	6332
.3432481 40′	.988282	.113457	6° 32′ 57″	.994773	.019555	.706288
	198	945			89 331	6342
.3461570 50′	.988084	.114402	6° 36′ 16″	.994684	.019886	.712630
	200	945			89 334	6352
.3490659 20′	.987884	.115347	6° 39′ 35″	.994595	.020220	.718982

θ	X		Y		ϕ	C		F		T
.3490659 20′	.987884		.115347		6° 39′ 35″	.994595		.020220		.718982
	———	202	———	944		———	90	———	337	———6362
.3519748 10′	.987682		.116291		6° 42′ 54″	.994505		.020557		.725344
		203		944			91		340	6372
.3548837 20′	.987479		.117235		6° 46′ 14″	.994414		.020897		.731716
		205		943			92		342	6381
.3577925 30′	.987274		.118178		6° 49′ 33″	.994322		.021239		.738097
		206		943			93		345	6391
.3607014 40′	.987068		.119121		6° 52′ 52″	.994229		.021584		.744488
		208		943			93		348	6401
.3636103 50′	.986860		.120064		6° 56′ 11″	.994136		.021932		.750889
	———	210	———	942		———	94	———	350	———6412
.3665191 21°	.986650		.121006		6° 59′ 31″	.994042		.022282		.757301
	———	211	———	942		———	95	———	353	———6422
.3694280 10′	.986439		.121948		7° 02′ 50″	.993947		.022635		.763723
		213		941			96		356	6433
.6723369 20′	.986226		.122889		7° 06′ 10″	.993851		.022991		.770156
		215		941			96		359	6443
.3752457 30′	.986011		.123830		7° 09′ 29″	.993755		.023350		.776599
		216		940			97		362	6454
.3781546 40′	.985795		.124770		7° 12′ 48″	.993658		.023712		.783053
		218		940			98		365	6465
.3810635 50′	.985577		.125710		7° 16′ 08″	.993560		.024077		.789518
	———	220	———	939		———	98	———	367	———6477
.3839724 22°	.985357		.126649		7° 19′ 27″	.993462		.024444		.795995
	———	221	———	939		———	99	———	370	———6487
.3868813 10′	.985136		.127588		7° 22′ 46″	.993363		.024814		.802482
		223		939			100		372	6498
.3897902 20′	.984913		.128527		7° 26′ 06″	.993263		.025186		.808980
		224		938			101		375	6510
.3926990 30′	.984689		.129465		7° 29′ 25″	.993162		.025561		.815490
		226		938			101		378	6521
.3956079 40′	.984463		.130403		7° 32′ 44″	.993061		.025939		.822011
		228		937			102		381	6533
.3985168 50′	.984235		.131340		7° 36′ 03″	.992959		.026320		.828544
	———	229	———	936		———	103	———	383	———6545
.4014257 23°	.984006		.132276		7° 39′ 22″	.992856		.026703		.835089
	———	231	———	936		———	104	———	386	———6557
.4043346 10′	.983775		.133212		7° 42′ 41″	.992752		.027089		.841646
		233		936			104		389	6568
.4072435 20′	.983542		.134148		7° 46′ 00″	.992648		.027478		.848214
		234		936			105		392	6580
.4101523 30′	.983308		.135084		7° 49′ 20″	.992543		.027870		.854794
		236		935			106		394	6592
.4130612 40′	.983072		.136019		7° 52′ 39″	.992437		.028264		.861386
		237		934			107		397	6605
.4159701 50′	.982835		.136953		7° 55′ 58″	.992330		.028661		.867991
	———	239	———	933		———	107	———	400	———6617
.4188790 24°	.982596		.137886		7° 59′ 17″	.992223		.029061		.874608
	———	241	———	933		———	108	———	402	———6630
.4217879 10′	.982355		.138819		8° 02′ 36″	.992115		.029463		.881238
		242		933			109		405	6643
.4246968 20′	.982113		.139752		8° 05′ 55″	.992006		.029868		.887881
		244		933			109		408	6655
.4276056 30′	.981869		.140685		8° 09′ 14″	.991897		.030276		.894536
		245		932			110		411	6669
.4305145 40′	.981624		.141617		8° 12′ 33″	.991787		.030687		.901205
		247		931			111		413	6682
.4334234 50′	.981377		.142548		8° 15′ 53″	.991676		.031100		.907887
	———	249	———	930		———	112	———	416	———6695
.4363323 25°	.981128		.143478		8° 19′ 12″	.991564		.031516		.914582

θ	X	Y	ϕ	C	F	T
.4363323 25′	.981128	.143478	8° 19′ 12″	.991564	.031516	.914582
	250 930			113 419		6709
.4392412 10′	.980878	.144408	8° 22′ 31″	.991451	.031935	.921291
	252 930			113 422		6722
.4421501 20′	.980626	.145338	8° 25′ 50″	.991338	.032357	.928013
	253 929			114 424		6736
.4450589 30′	.980373	.146267	8° 29′ 08″	.991224	.032781	.934749
	255 929			115 427		6750
.4479678 40′	.980118	.147196	8° 32′ 27″	.991109	.033208	.941499
	257 928			115 429		6763
.4508767 50′	.979861	.148124	8° 35′ 46″	.990994	.033637	.948262
	258 928			116 432		6776
.4537856 26°	.979603	.149052	8° 39′ 05″	.990878	.034069	.955038
	260 927			117 435		6791
.4566945 10′	.979343	.149979	8° 42′ 24″	.990761	.034504	.961829
	261 926			118 438		6806
.4596034 20′	.979082	.150905	8° 45′ 43″	.990643	.034942	.968635
	263 926			118 440		6821
.4625122 30′	.978819	.151831	8° 49′ 02″	.990525	.035382	.975456
	264 926			119 443		6835
.4654211 40′	.978555	.152757	8° 52′ 21″	.990406	.035825	.982291
	266 925			120 446		6850
.4683300 50′	.978289	.153682	8° 55′ 40″	.990286	.036271	.989141
	268 924			121 448		6865
.4712389 27°	.978021	.154606	8° 58′ 59″	.990165	.036719	.996006
	269 924			121 451		6881
.4741478 10′	.977752	.155530	9° 02′ 18″	.990044	.037170	1.002887
	271 923			122 454		6896
.4770567 20′	.977481	.156453	9° 05′ 37″	.989922	.037624	1.009783
	273 922			123 456		6911
.4799655 30′	.977208	.157375	9° 08′ 56″	.989799	.038080	1.016694
	274 922			124 459		6927
.4828744 40′	.976934	.158297	9° 12′ 15″	.989675	.038539	1.023621
	276 922			124 462		6942
.4857833 50′	.976658	.159219	9° 15′ 34″	.989551	.039001	1.030563
	277 921			125 465		6958
.4886922 28°	.976381	.160140	9° 18′ 52″	.989426	.039466	1.037521
	279 920			126 467		6974
.4916011 10′	.976102	.161060	9° 22′ 11″	.989300	.039933	1.044495
	281 920			126 470		6991
.4945100 20′	.975821	.161980	9° 25′ 30″	.989174	.040403	1.051486
	282 919			127 472		7007
.4974188 30′	.975539	.162899	9° 28′ 48″	.989047	.040875	1.058493
	283 919			128 475		7023
.5003277 40′	.975256	.163818	9° 32′ 07″	.988919	.041350	1.065516
	285 918			129 478		7041
.5032366 50′	.974971	.164736	9° 35′ 26″	.988790	.041828	1.072557
	287 917			129 481		7058
.5061455 29°	.974684	.165653	9° 38′ 44″	.988661	.042309	1.079615
	288 917			130 483		7075
.5090544 10′	.974396	.166570	9° 42′ 03″	.988531	.042792	1.086690
	290 916			131 486		7092
.5119633 20′	.974106	.167486	9° 45′ 21″	.988400	.043278	1.093782
	292 916			131 488		7109
.5148721 30′	.973814	.168402	9° 48′ 40″	.988269	.043766	1.100891
	293 915			132 491		7127
.5177810 40′	.973521	.169317	9° 51′ 59″	.988137	.044257	1.108018
	295 914			133 494		7144
.5206899 50′	.973226	.170231	9° 55′ 17″	.988004	.044751	1.115162
	296 914			134 497		7162
.5235988 30°	.972930	.171145	9° 58′ 36″	.987870	.045248	1.122324

θ		X	Y	ϕ	C	F
.5235988	30°	.972930	.171145	9° 58′ 36″	.987870	.045248
		898	2738		407	1505
.5323254	30′	.972032	.173883	10° 08′ 32″	.987463	.046753
		912	2732		413	1530
.5410521	31°	.971120	.176615	10° 18′ 27″	.987050	.048283
		925	2726		419	1553
.5497787	30′	.970195	.179341	10° 28′ 23″	.986631	.049836
		940	2721		426	1577
.5585054	32°	.969255	.182062	10° 38′ 18″	.986205	.051413
		954	2714		432	1600
.5672320	30′	.968301	.184776	10° 48′ 13″	.985773	.053013
		968	2709		439	1625
.5759587	33°	.967333	.187485	10° 58′ 08″	.985334	.054638
		982	2703		445	1648
.5846853	30′	.966351	.190188	11° 18′ 03″	.984889	.056286
		995	2696		452	1671
.5934119	34°	.965356	.192884	11° 17′ 57″	.984437	.057957
		1010	2690		459	1695
.6021385	30′	.964346	.195574	11° 27′ 52″	.983978	.059652
		1023	2685		465	1718
.6108652	35°	.963323	.198259	11° 37′ 46″	.983513	.061370
		1036	2677		471	1742
.6195918	30′	.962287	.200936	11° 47′ 40″	.983042	.063112
		1050	2671		478	1766
.6283185	36°	.961237	.203607	11° 57′ 34″	.982564	.064878
		1064	2665		485	1788
.6370451	30′	.960173	.206272	12° 07′ 28″	.982079	.066666
		1078	2658		491	1812
.6457718	37°	.959095	.208930	12° 17′ 22″	.981588	.068478
		1091	2651		497	1834
.6544984	30′	.958004	.211581	12° 27′ 15″	.981091	.070312
		1104	2645		504	1858
.6632251	38°	.956900	.214226	12° 37′ 08″	.980587	.072170
		1118	2637		511	1881
.6719517	30′	.955782	.216863	12° 47′ 01″	.980076	.074051
		1131	2631		517	1904
.6806784	39°	.954651	.219494	12° 56′ 54″	.979559	.075955
		1144	2623		523	1927
.6894050	30′	.953507	.222117	13° 06′ 47″	.979036	.077882
		1158	2617		530	1950
.6981317	40°	.952349	.224734	13° 16′ 40″	.978506	.079832
		1171	2609		537	1972
.7068583	30′	.951178	.227343	13° 26′ 32″	.977969	.081804
		1184	2602		543	1996
.7155850	41°	.949994	.229945	13° 36′ 24″	.977426	.083800
		1198	2594		549	2018
.7243116	30′	.948796	.232539	13° 46′ 16″	.976877	.085818
		1210	2587		556	2040
.7330383	42°	.947586	.235126	13° 56′ 08″	.976321	.087858
		1224	2580		562	2063
.7417649	30′	.946362	.237706	14° 05′ 59″	.975759	.089921
		1236	2572		568	2086
.7504916	43°	.945126	.240278	14° 15′ 50″	.975191	.092007
		1249	2564		575	2108
.7592182	30′	.943877	.242842	14° 25′ 41″	.974616	.094115
		1262	2557		582	2130
.7679449	44°	.942615	.245399	14° 35′ 32″	.974034	.096245
		1275	2548		588	2153
.7766715	30′	.941340	.247947	14° 45′ 23″	.973446	.098398
		1288	2541		594	2175
.7853982	45°	.940052	.250488	14° 55′ 14″	.972852	.100573

θ		X	Y	ϕ	C	F
.7853982	45°	.940052	.250488	14° 55′ 14″	.972852	.100573
		1301	2533		600	2197
.7941248	30′	.938751	.253021	15° 05′ 04″	.972252	.102770
		1313	2525		607	2219
.8028515	46°	.937438	.255546	15° 14′ 54″	.971645	.104989
		1326	2516		613	2241
.8115781	30′	.936112	.258062	15° 24′ 44″	.971032	.107230
		1338	2509		620	2263
.8203047	47°	.934774	.260571	15° 34′ 33″	.970412	.109493
		1351	2500		626	2285
.8290313	30′	.933423	.263071	15° 44′ 23″	.969786	.111778
		1363	2491		632	2306
.8377580	48°	.932060	.265562	15° 54′ 12″	.969154	.114084
		1375	2483		639	2329
.8464846	30′	.930685	.268045	16° 04′ 01″	.968515	.116413
		1388	2475		645	2350
.8552113	49°	.929297	.270520	16° 13′ 49″	.967870	.118763
		1401	2466		651	2371
.8639379	30′	.927896	.272986	16° 23′ 38″	.967219	.121134
		1412	2457		657	2393
.8726646	50°	.926484	.275443	16° 33′ 26″	.966562	.123527
		1425	2449		664	2415
.8813912	30′	.925059	.277892	16° 43′ 14″	.965898	.125942
		1436	2440		670	2435
.8901179	51°	.923623	.280332	16° 53′ 02″	.965228	.128377
		1449	2431		676	2457
.8988445	30′	.922174	.282763	17° 02′ 49″	.964552	.130834
		1460	2422		683	2478
.9075712	52°	.920714	.285185	17° 12′ 36″	.963869	.133312
		1473	2413		689	2500
.9162978	30′	.919241	.287598	17° 22′ 23″	.963180	.135812
		1484	2403		695	2520
.9250245	53°	.917757	.290001	17° 32′ 10″	.962485	.138332
		1497	2395		701	2541
.9337511	30′	.916260	.292396	17° 41′ 56″	.961784	.140873
		1507	2385		708	2562
.9424778	54°	.914753	.294781	17° 51′ 42″	.961076	.143435
		1520	2376		713	2583
.9512044	30′	.913233	.297157	18° 01′ 28″	.960363	.146018
		1531	2367		720	2603
.9599311	55°	.911702	.299524	18° 11′ 13″	.959643	.148621
		1544	2357		726	2624
.9686577	30′	.910158	.301881	18° 20′ 59″	.958917	.151245
		1553	2348		732	2645
.9773844	56°	.908605	.304229	18° 30′ 44″	.958185	.153890
		1566	2338		738	2665
.9861110	30′	.907039	.306567	18° 40′ 29″	.957447	.156555
		1577	2329		745	2686
.9948377	57°	.905462	.308896	18° 50′ 13″	.956702	.159241
		1588	2318		751	2706
1.0035643	30′	.903874	.311214	18° 59′ 57″	.955951	.161947
		1599	2309		757	2726
1.0122910	58°	.902275	.313523	19° 09′ 41″	.955194	.164673
		1611	2299		763	2746
1.0210176	30′	.900664	.315822	19° 19′ 25″	.954431	.167419
		1621	2289		768	2766
1.0297443	59°	.899043	.318111	19° 29′ 08″	.953663	.170185
		1633	2279		775	2786
1.0384709	30′	.897410	.320390	19° 38′ 51″	.952888	.172971
		1643	2270		782	2806
1.0471976	60°	.895767	.322660	19° 48′ 33″	.952106	.175777

θ	X	Y	ϕ	C	F
1.0471976 60′	.895767	.322660	19° 48′ 33″	.952106	.175777
	1655	2259		787	2825
1.0559242 30′	.894112	.324919	19° 58′ 16″	.951319	.178602
	1665	2248		793	2845
1.0646508 61′	.892447	.327167	20° 07′ 58″	.950526	.181447
	1676	2239		799	2865
1.0733774 30′	.890771	.329406	20° 17′ 40″	.949727	.184312
	1687	2228		806	2884
1.0821041 62′	.889084	.331634	20° 27′ 21″	.948921	.187196
	1697	2218		811	2904
1.0908307 30′	.887387	.333852	20° 37′ 02″	.948110	.190100
	1708	2207		818	2923
1.0995574 63°	.885679	.336059	20° 46′ 43″	.947292	.193023
	1718	2197		823	2942
1.1082840 30′	.883961	.338256	20° 56′ 24″	.946469	.195965
	1729	2186		829	2962
1.1170107 64′	.882232	.340442	21° 06′ 04″	.945640	.198927
	1739	2176		836	2980
1.1257373 30′	.880493	.342618	21° 15′ 44″	.944804	.201907
	1749	2165		842	3000
1.1344640 65°	.878744	.344783	21° 25′ 23″	.943962	.204907
	1760	2155		847	3018
1.1431906 30′	.876984	.346938	21° 35′ 02″	.943115	.207925
	1769	2143		853	3036
1.1519173 66°	.875215	.349081	21° 44′ 41″	.942262	.210961
	1780	2133		859	3056
1.1606439 30′	.873435	.351214	21° 54′ 19″	.941403	.214017
	1789	2122		865	3074
1.1693706 67°	.871646	.353336	22° 03′ 57″	.940538	.217091
	1800	2110		871	3093
1.1780972 30′	.869846	.355446	22° 13′ 35″	.939667	.220184
	1809	2100		877	3111
1.1868239 68°	.868037	.357546	22° 23′ 13″	.938790	.223295
	1819	2089		882	3129
1.1955505 30′	.866218	.359635	22° 32′ 50″	.937908	.226424
	1828	2077		889	3148
1.2042772 69°	.864390	.361712	22° 42′ 26″	.937019	.229572
	1839	2067		894	3166
1.2130038 30′	.862551	.363779	22° 52′ 03″	.936125	.232738
	1847	2055		900	3183
1.2217305 70	.860704	.365834	23° 01′ 39″	.935225	.235921
	1857	2044		906	3202
1.2304571 30′	.858847	.367878	23° 11′ 15″	.934319	.239123
	1867	2032		912	3219
1.2391838 71°	.856980	.369910	23° 20′ 50″	.933407	.242342
	1876	2022		918	3237
1.2479104 30′	.855104	.371932	23° 30′ 25″	.932489	.245579
	1885	2009		923	3255
1.2566371 72°	.853219	.373941	23° 39′ 59″	.931566	.248834
	1894	1998		929	3272
1.2653637 30′	.851325	.375939	23° 49′ 33″	.930637	.252106
	1903	1987		935	3289
1.2740904 73°	.849422	.377926	23° 59′ 07″	.929702	.255395
	1912	1975		941	3306
1.2828170 30′	.847510	.379901	24° 08′ 40″	.928761	.258701
	1921	1963		946	3324
1.2915436 74°	.845589	.381864	24° 18′ 13″	.927815	.262025
	1930	1951		952	3341
1.3002702 30′	.843659	.383815	24° 27′ 46″	.926863	.265366
	1939	1940		958	3358
1.3089969 75°	.841720	.385755	24° 37′ 18″	.925905	.268724

θ	X	Y	ϕ	C	F
1.3089969 75°	.841720	.385755	24° 37′ 18″	.925905	.268724
	—1947	—1928		— 964	—3374
1.3177235 30′	.839773	.387683	24° 46′ 50″	.924941	.272098
	1956	1916		969	3392
1.3264502 76°	.837817	.389599	24° 56′ 21″	.923972	.275490
	1964	1904		975	3408
1.3351768 30′	.835853	.391503	25° 05′ 52″	.922997	.278898
	1973	1893		980	3425
1.3439035 77°	.833880	.393396	25° 15′ 23″	.922017	.282323
	1981	1880		986	3441
1.3526301 30′	.831899	.395276	25° 24′ 53″	.921031	.285764
	1990	1868		992	3457
1.3613568 78°	.829909	.397144	25° 34′ 23″	.920039	.289221
	1998	1856		997	3474
1.3709834 30′	.827911	.399000	25° 43′ 52″	.919042	.292695
	2005	1844		1003	3490
1.3788101 79°	.825906	.400844	25° 53′ 21″	.918039	.296185
	2014	1832		1008	3506
1.3875367 30′	.823892	.402676	26° 02′ 49″	.917031	.299691
	—2022	—1820		—1014	—3522
1.3962634 80°	.821870	.404496	26° 12′ 17″	.916017	.303213
	—2030	—1807		—1019	—3538
1.4049900 30′	.819840	.406303	26° 21′ 45″	.914998	.306751
	2037	1795		1025	3554
1.4137167 81°	.817803	.408098	26° 31′ 12″	.913973	.310305
	2045	1783		1031	3569
1.4224433 30′	.815758	.409881	26° 40′ 39″	.912942	.313874
	2053	1770		1036	3585
1.4311700 82°	.813705	.411651	26° 50′ 05″	.911906	.317459
	2060	1758		1041	3600
1.4398966 30′	.811645	.413409	26° 59′ 31″	.910865	.321059
	2068	1745		1047	3615
1.4486233 83°	.809577	.415154	27° 08′ 56″	.909818	.324674
	2075	1733		1053	3631
1.4573499 30′	.807502	.416887	27° 18′ 21″	.908765	.328305
	2082	1721		1058	3646
1.4660766 84°	.805420	.418608	27° 27′ 46″	.907707	.331951
	2090	1708		1063	3660
1.4748032 30′	.803330	.420316	27° 37′ 10″	.906644	.335611
	—2097	—1695		—1068	3675
1.4835299 85°	.801233	.422011	27° 46′ 33″	.905576	.339286
	—2103	—1682		—1074	—3690
1.4922565 30′	.799130	.423693	27° 55′ 56″	.904502	.342976
	2111	1670		1079	3705
1.5009832 86°	.797019	.425363	28° 05′ 19″	.903423	.346681
	2118	1657		1085	3719
1.5097098 30′	.794901	.427020	28° 14′ 41″	.902338	.350400
	2124	1644		1090	3733
1.5184364 87°	.792777	.428664	28° 24′ 02″	.901248	.354133
	2131	1631		1095	3748
1.5271630 30′	.790646	.430295	28° 33′ 23″	.900153	.357881
	2137	1619		1101	3762
1.5358897 88°	.788509	.431914	28° 42′ 44″	.899052	.361643
	2145	1606		1106	3777
1.5446163 30′	.786364	.433520	28° 52′ 04′	.897946	.365420
	2150	1592		1111	3790
1.5533430 89°	.784214	.435112	29° 01′ 24″	.896835	.369210
	2157	1580		1116	3804
1.5620696 30′	.782057	.436692	29° 10′ 43″	.895719	.373014
	—2163	—1567		—1121	—3817
1.5707963 90°	.779894	.438259	29° 20′ 01″	.894598	.376831

TOPICAL QUESTION No. 3.

What is the Effect of Modern Brakes upon the Railway and its Supporting Structures?

The Secretary read the question, and stated that the subject had been recently brought up. It had been suggested to the Society that the powerful brakes employed in checking the velocity of a running train must have an injurious effect upon the track, particularly in curves and upon all structures that constitute the support of the railway, that is, wherever such effective devices are injudiciously applied. Considering that the greater part of the energy of a moving train, if suddenly checked, is taken up by the track, does not the modern brake become an element of danger, and, if so, to what extent?

Are there reasons for assuming in the case of a bridge, say a draw bridge, that energy imparted to the structure continuously may ultimately lead to the destruction of it?

Mr. von Geldern related an instance, vouched for by observations made by Mr. Hector von Bayer, a civil engineer of Washington, D. C., which might go to show that the subject was one worthy of closer inquiry.

This gentleman had occasion to examine the draw bridge over the Genessee River, at Charlotte, near Lake Ontario, and noticed that the station on the west side of the stream lay in close proximity to the bridge. Trains approaching from the east would apply their brakes while crossing the stream in order to make a halt as soon as the bridge was passed. Shortly after the completion of this structure it was noticed that it began to jam against the stone wall of the western abutment, and that it could not be turned without first chiseling off the stone facing. This operation was repeated at intervals by stone masons, whom he observed at work from time to time on the western abutment, while the corresponding gap at the eastern end was just as frequently bridged over by lengthening the rails to compensate for the cut on the opposite side.

There was every indication that the bridge traveled westward, in the direction of the moving trains. Watching a train approaching and seeing the brakes applied while crossing the bridge at a fair speed, he observed that as soon as the train felt the check the entire structure was thrown toward the western abutment until it brought up against its wall. The center or turning pier was measured sub-

sequently, and found to have a considerable leaning to westward, to such an extent that the observer thought it necessary that this pier be replaced at an early date. The whole condition of affairs proved to him that the bridge was unsafe, and made so by an injudicious application of the air brake, continued from day to day.

"This is the only case ever brought to notice, as far as we are here aware," the Secretary stated, "and we shall aim in discussing this subject, to ascertain whether similar observations have ever been made before."

In order to begin the discussion, the following communication was read from Mr. D. E. Hughes, of Irvington, Cal.

CONCERNING THE EFFECTS OF BRAKES.

"Not being a railway engineer, hence not touched by the invitation for written replies, and not having given this important question much consideration, my only excuse for offering this, is that, whether by truth or by error, it may present a phase that abler men will discuss to our edification.

I shall try to point out the forces that a moving train imparts by means of brakes to the road-bed, but will not dwell here on the importance of not overlooking them when designing curved trestles, draw-spans, cantilevers, suspension bridges, etc., nor ask if they have *always* received the considerations that their magnitude demands.

There is no need to tell here the old story of the kinetic energy of the moving train and revolving wheels being never lost, but transformed, producing heat and other molecular disturbances, for, however interesting this may be to the physicist, it does not so much concern the engineer. Suffice it to say that living force can not be transformed without the opposition of some other force outside of the moving body. Suppose a train running on a straight, level track and gravity suspended. It will go off on a tangent. Stop the engine, and put on the brakes. Most of the kinetic energy in the revolving wheels will be transformed into heat, etc. The rest is shared with the train till all revolve slowly together, the center of gravity however pursuing a straight line with velocity unchanged. The living force in the revolving wheels has been modified by means of the static force holding the break and journal boxes. Now with the train on the track, and gravity not cut off, the tendency to slow rotation is overcome by the front end of cars and trucks pressing the track more and the rear end less than when brakes are off.

To stop the train the whole of the living force of *translation* is opposed by a horizontal force acting lengthwise in the rail. The brake is only a means for calling this into play. The heat and wearing away of brake shoes, etc., is only the result of this opposition. The help air offers in stopping a heavy train is considered too small to be regarded here. Suppose a truck jacked up and the brake on. We must apply at the circumference considerable tangential force to turn the wheels. This is just what the track does when the train is moving and the brakes are on, except that the latter is less when brakes are first applied, because the energy of rotation in the wheels helps then to keep them turning; and it is a little more later, because journal friction, under the load, is greater. It is generally the *maximum*, longitudinal, track strain that must be provided against. This occurs when brakes are applied to all the wheels at once, and just tight enough that the wheels may be on the verge of skidding. The effect of it on the supporting structure is greater when this maximum condition is quickly attained, being like the effect on a beam or pillar of applying a load suddenly, that is, it approaches twice what it is later.

The intensity of the track force, when maximum, is independent of velocity of train. Its amount equals weight of train multiplied by coefficient of *static* friction, about $\frac{1}{3}$. When, as is the case with heavier trains, the wheel load is so great that the limit of abrasion is passed and the wheels sink into the rails, the "coefficient of adhesion" must be substituted for the above. This will reach $\frac{2}{3}$, that is, a 600-ton train with any velocity may develop in the supporting structure a horizontal strain of 200 tons. If the wheels are sliding, weight must be multiplied by coefficient of *kinetic* friction, which is variable, depending on the velocity, but never greater than the above.

Although foreign to the brake question it may be noticed here that when the engine is reversed to help make the stop the forward push in the road-bed is augmented. The calculation of this additional strain involves the use of the rate of revolution of the drivers and of a very uncertain coefficient of kinetic friction. The total strain can be approximated, however, by dividing the kinetic energy of the train by the distance in which the stopping is effected; for example: suppose a 200-ton train moving 60 miles per hour, or 88 feet per second, stopped in 600 feet. $k.\,e. = \frac{w\,v^2}{2\,g} = \frac{200 \times 88^2}{2 \times 32.16} =$ 24,080 foot-tons, and $24{,}080 \div 600 = 40$ tons *average*. The result is much less than the *maximum*, because the conditions of highest efficiency for stopping do not obtain throughout.

Concerning the forward push in the rails:

Ordinarily it is transmitted to the ground within a distance but little, if any, greater than the length of the train. On a bridge it must be met by the stability of the piers, or else means must be provided for its transmission to the shores. On a curve, if the force is not transferred to the ground within the train length, the tendency is to straighten the track behind the train, and buckle it ahead. If the curve is on a trestle the derangement must be provided against. The intensity of the force to be met in this case may be determined thus: Let the forces imparted to the structure by the several cars, assumed equal, be represented by car lengths of track under them, then the closing side of the polygon is the resultant, that is, the chord extending from rear to front of a train represents the deranging force. If the several "bents" are able to withstand a part of the force in question then diminish the resultant accordingly. If the curve is completely covered by a train of uniform weight and brake action, there is no *radial* force except the centrifugal that would obtain at that velocity without the brakes.

At a station entered only one way there may be a creeping of the rails, for the push of stopping trains is all one way, and in the same direction is the pull at starting although less, for the car wheels are not drivers. Such creeping does not necessarily imply an *appreciable* slip. It may be the result of an oft repeated short wave of compression traveling just ahead of the braked wheel.

The increased pressure thrown on front drivers when the locomotive is stopping is of much importance. Some of it has already been accounted for. The rest, and by far the greater part, is due to the following: The force that the brake calls into play to stop the locomotive is not directed toward its center of gravity but along the rails below it. This produces a tendency to rotation much greater than the other, and, like it, is overcome by the *couple*, manifested in an increase of pressure at the front end and a diminution at the other.

As an illustration of this last point, suppose a 60-ton locomotive all on two pair of drivers, 8 feet apart, and center of gravity midway between them, and 4 feet above the track. When brakes are applied the track force may reach $60 \times \frac{1}{3} = 20$ tons. This is one component, and the equal "stream" opposing it, acting in opposite direction 4 feet above it, is the other component of the couple tending to produce rotation. Its moment is $20 \times 4 = 80$ foot tons. This is

opposed by the vertical couple acting through the wheels, of which either component equals $80 \div 8 = 10$ tons, producing in front wheels a pressure of $30 + 10$, and in the other pair $30 - 10$ tons.

DISCUSSION.

Mr. W. G. Curtis.—"I agree with what Mr. Hughes has said in his paper, in the main. We have had occasion to look into the subject from time to time. The quick-action brake was introduced some four or five years ago. We have found in railway construction that when bridges and viaducts are made of ample strength to support heavy trains, that they will resist any possible effect of friction as between the rail and the wheel when the automatic brakes are applied in their full force. The automatic brake does not act with quite the suddenness of a blow; it takes three or four seconds to get the full force of the brake on trains of fifty freight cars. Under shorter trains the emergency application is made in a little shorter time. The present practice is to apply a pressure through the brake shoes against wheel treads equal to about 90 per cent. of the weight upon the braked wheels (including weight of wheels.) The recent practice is to apply brakes to all the wheels. The heavy Pullman, and other cars having twelve wheels, are provided with brakes for each wheel, introducing what is called the "triple brake."

Locomotives are commonly provided with brakes applied to driving wheels and tender wheels, but the maximum effect in braking of the driving wheels, as stated by Mr. Hughes, is caused by reversing the engine, which the engineer can do at will in emergencies. The weight resting upon the rail per wheel, for modern standard cars, being less than 10,000 pounds, the maximum coefficient of sliding friction as between the brake shoes and wheels, and the wheels and rails, may be safely assumed at 25 per cent. of the weight or pressure. This coefficient, for modern locomotive driving wheels, carrying weights of 17,000 pounds or more per wheel, may, as a maximum, be assumed at 35 per cent. of the weight resting upon the rail, or the pressure applied through the brake shoes. On this basis, the total force applied along the line of the top of the rail when the automatic brakes are on at their full pressure, can be readily estimated. For example, if a Pullman car weighs 90,000 pounds, and brake 90 per cent. of that, that would be 81,000 pounds, and a quarter of that, say 20,000 pounds, would be the force applied

along the top of the rail; but just how this goes into a structure is a little complicated and difficult to ascertain.

When the brakes are applied, heat is very rapidly developed in the wheel and brake shoe, the latter very frequently becoming redhot. Of course, that energy could not be developed and make itself visible in that form unless somewhere there was resistance. That resistance is in the rail and supporting structure, no doubt, and the energy which is not converted into heat is expended in compressing the rail; the tendency of a train moving with brakes applied is to drag the rail along with it—to compress the rail in front, and extend it behind.

I have stood under bridges and observed the effect of applying brakes when the train was running 40 miles an hour, and in all investigations into this matter taken up from time to time, as new brake equipments have been made and perfected, I have been led to the conclusion that in the designing of railway bridges or viaducts, the effect of brake application under trains carried by such structures need not be considered, for the reason that the strength of the rails, guard timbers, track stringers, etc., if adequate to carry a free rolling load or trains, and providing for all requirements of safety in floor system, will always be of ample strength to resist so much of the energy stored up in moving trains, as can be applied to produce longitudinal stress along the rails through the application of the air brakes."

Q.—"On curved trestles it would have the most effect. What provision would you make to meet it?"

A.—"From what I know of the subject, there is nothing to lead me to think that any special precautions are necessary."

Q.—"On long structures is it not always the custom to slow down?"

A.—"Not invariably. I don't think there have been any railway accidents that can be traced to brake action, but so far as my reading goes the literature of this subject is rather meager."

A PAPER ON GRIPS AND BRAKES OF STREET CABLE RAILWAYS.

By Alexander Watson, Engineer.

[Presented April 1st, 1892.]

From only eleven cities of the Union we have reports of thirteen cable accidents in ten days of the present month of March, all of which were destructive of life or property, furnishing a ratio of 468 occurrences annually.

Most of these accidents are attributable to the inefficiency of brakes, or mistakes on the part of brakemen. The record is as follows :

March	3rd	San Francisco	Runaway Car.
"	7th	" "	Runaway Car.
"	13th	Baltimore	Collision.
"	15th	Harrisburg	Jumped the track.
"	16th	"	Broken grip.
"	16th	Denver	Collision.
"	17th	New York	Collision.
"	17th	Buffalo	Collision.
"	18th	Los Angeles	Collision.
"	18th	Tacoma	Collision.
"	19th	Cleveland	Jumped the track.
"	21st	Kansas	Collision.
"	23rd	St. Louis	Collision.

Now, if we heard of 468 boiler explosions taking place annually in only eleven cities, a remedy would be quickly found. But the fact is the cable system has come upon us so suddenly, and with so many startling advantages, that the public have hardly had time to consider the many dangerous contingencies connected with this new mode of traction.

The gripman's precarious hold upon the tail of a monster representing one thousand horse power, far removed from his control, is one of the principal factors occurring to the mind, because accidents may result alike from his hold suddenly breaking loose, or, on the other hand, from his grip refusing to let go. This risk attending the engineer's grasp of a rope, moving at a speed of eight miles an hour, is also enhanced by the fact that the iron hand that grasps the rope is out of sight, and therefore beyond the intelligent control of the most skillful mechanic.

While the risks accompanying this new mode of traction—hauling from a distance—are not readily apprehended on a level surface,

they present a significance when transferred to the steep grades, where additional precautions against accident hardly reconcile the traveling public to the feeling of safety, when the force of gravity has laid hold of four or five tons weight on wheels.

Having given the subject some attention during the past ten years, the writer's conclusions may possibly aid practical engineers in designing some specific for the safety of our fellow citizens who live in high places.

With regard to grips. There are many in existence, but few of them have been tested in a practical way.

The first grip employed on an iron cable was that used forty years ago on the steep grade at the Glasgow terminus of the North British Railway. It was simply a tapered skein of rope, similar to the Chinaman's queue, attached to the front of the train by a ring bolt. The several strands were twisted conversely around the iron rope in such a manner that the greater the strain the tighter it held. The cable was then set in motion by a stationary engine, and when the train reached the summit of the grade the hempen grip was let go from the ring-bolt by the engineer, and the stationary engine was stopped before this grip could be dragged under ground. This simple appliance (believed to have been the invention of a sailor), proved to be most efficient in hauling the heaviest trains up the steep grade, but would, of course be inapplicable to a cable which is constantly in motion.

It may be said that any style of grip in our present system is unreliable, because the condition and action of the appliance is hidden from the engineer in charge, who is wholly dependent upon his sense of touch, in judging of the working condition of his grip. The intelligent eye is ignored.

Cable brakes are not so diversified as grips. There are three classes, viz:

1. Wheel brakes.
2. Track, or rail brakes.
3. Slot brakes.

The efficiency of a wheel brake greatly depends upon the solidity of the axle bearings, because, where the whole axle is allowed any perpendicular play, the brake on the periphery of the wheels is rendered inefficient.

Much also depends upon the weight of the brake car, which on steep grades, should be much heavier than the passenger car. For those reasons the brake car should be constructed with a rigid

iron frame, and the wheel axles should run in solid bearings, the springs for the body of the car being placed on the rigid frame, and the box springs at the axle abolished. The brake car should be a distinct institution, and detachable from the passenger car, so as to provide against accident in the event of a flaw in the cable overtaking the grip.

The track brake, as at present applied, depends upon the weight of one man to shift the weight of the car from the wheels to the track brake, and is consequently too slow for an emergency, since one man's power is only equal to lift 133 pounds one inch in five seconds, it can readily be seen, that the efforts of a single man can effect but little when applied to the weight of a car (4 to 5 tons) on an emergency. With the track brake it has been proposed to employ sand boxes, an appliance which is a great help to the ordinary locomotive on a slippery rail; but in the case of cable cars, the wheels being hauled and not propelled, the application of sand would only add "fuel to the flame."

The slot brake is an absurdity, being contrary to mechanical principles. No engineer thinks of suddenly arresting the velocity of a body in rapid motion. Moreover, it is found that a wedge thrust into a slot on an incline will smash up when it reaches a level crossing, consequently becoming useless for the next steep grade. It is for this reason, presumably, that the brakemen on the lines where the slot brake is carried, appear to have some hesitation in using it. When the wedge is resorted to, it should be applied between the wheel and the rail, as in the old-fashioned shoe brake on common roads. By this means the maximum amount of friction is obtainable automatically, and the flat wearing or skidding of the wheel is prevented.

While much may be accomplished by an improved system of grips and brakes, there is room for improvement in our cable system generally. The gripmen in charge of our dummies should be regularly trained to the use of the emergency brakes, aside from ordinary traffic training. This could be done by daylight in the early morning on the successive hills without danger to anyone. It does not seem fair to a green hand that he should be exposed to an emergency on our steep hills without previous training. Unless this is done the public are not safe. Another remedy should be applied, so as to control the number of trips. At first sight it would appear to be a great public convenience to step on a Market street car every few seconds of the day, but, when the interest of the greater number

(pedestrians) is considered, the present system is rather an obstruction to traffic.

Any day in business hours, at the junction of our principal streets, may be witnessed the effects of the present practice of unlimited cars. An annoying procession of cars, loaded and empty, hinders for many minutes the safe crossing of hundreds of pedestrians, whose time and avocations are not less important to the community than those represented in the continuous string of cable cars.

By some regulation of the cable traffic, it is the incumbent duty of the Board of Supervisors to reduce to a minimum the great risk of collision with persons and vehicles. If pedestrians had the benefit of some provision limiting the number of trips, and lengthening the intervals between cars crossing our main thoroughfares, the street railways would also reap the benefit of immunity from damage suits to the extent of hundreds of thousands of dollars annually.

A TOPOGRAPHICAL SURVEY OF CALIFORNIA.

BY PROF. WILLARD D. JOHNSON, U. S. GEOLOGICAL SURVEY.

[An Address Made April 1st, 1892.]

I have been invited to lay before you a recently proposed plan for a systematic topographic survey of the valley areas of California —a plan involving coöperation of the State government with the Geological Survey Bureau of the Federal Government.

I will go into the matter at present in outline only, as an announcement to the Technical Society. Before it could be said that such a proposition had been made authoritatively, it must have received generally the endorsement of engineers. To that end I have been asked to state to you the proposition.

To propose a systematic survey, is to imply that such a survey has not yet been made, and members of the Technical Society will recall the detailed leveling and transit meandering of the recent Engineers' Department, and of the State Commission on Rivers and Harbors, yet it is true that that accurate work could be regarded only as scattered contributions to a complete topographic map. California has had a succession of State surveys, each in some degree topographic in its aims, and not only have the results been admirable, but, it has seemed to me, especially as regards Mr. Hall's reports, that recognition of their scientific and practical value has been more appreciative outside the State than within it. Yet as the plans in each case were only incidentally for map work, and in no case completely carried out, the map material is of uneven value, disconnected, and not considerable in amount. Especially it has not been thoroughly coördinated by triangulation, but has in the main been hung to the distorted rectangular system of the Land Office.

It is now proposed to have made a systematic and uniform contour map survey of all the valley and foot-hill areas of the State, to be engraved in atlas sheets of a quarter degree square each, on a scale of one inch to one mile. Each of these sheets—a quadrilateral of the earth's surface, 15 minutes extent in latitude and longitude—would include an area, varying slightly with the latitude, averaging 238 square miles ; an equivalent of about six and a half townships. The paper dimensions of each sheet, with margins would be 16 inches by 20 inches. To join these quarter degree units into a single sheet, would be to give to the great central valley alone a length of 50 feet, and to the whole State (if this inch-to-a-mile work were to

be so far extended) a length of nearly 100 feet. It is estimated that for the valley and foot-hill areas the number of atlas sheets would be 140. This map would be designed for general purposes ; it would not be a cadastral map ; that is, it would not show private property boundaries, but it would be a topographic map, portraying the topography, or the relief of the surface, by the modern contour method, and exhibiting in addition the drainage system ; the water bodies ; the public property, or political boundaries ; the settlements ; the railways, and the public roads ; and the canals and irrigation waterways, not of individual ownership ; in short, the map would depict, on the one hand, the natural features, and, on the other hand, the public "cultural" features.

As regards the question of desirability merely, it would seem that instant assent might be had in any intelligent community. Such will nowhere, however, be the case. The need is of too general a nature, and hard to particularize. There is nearly everywhere in the United States, as yet, lack of sufficient example. We are far behind European progress in this respect. Bearing on this question of general utility, let me outline a single illustration.

In this State, agricultural development means, in an unusual degree, irrigation development, and, if the valley areas, which comprise all the habitable and agricultural lands, are to share in the relatively dense settlement of the future United States, they must be prepared for a population of millions, and a population dependent upon complex systems of irrigation. Such systems must inevitably become greatly elaborated in detail, and elaboration will, in a measure, be a matter of natural growth, not to be deliberately planned, but to be directed by circumstances. Complexity is inherent in the irrigation problem, for there are many factors, and under the best proportioned scheme, puzzling alternatives must present themselves as development approaches the extreme attainable limits of expansion ; but an unnecessary complexity, arresting development, is early introduced where there is not full information that will indicate all the factors, and that will outline the remote maximum possibilities. From such arrested development escape will mean a radical remodeling and an abandonment of much costly inadequate work. There is not lacking in California illustration of haphazard and bad beginnings in irrigation development, though there are several brilliant examples of thorough engineering work that the rest of the West is following ; work that must be vastly extended and greatly diversified. All the irrigable and otherwise cultivable

areas of the State are yet at the beginnings of their settlement, and their future is to a larger degree than anywhere in the East a matter of engineering forethought and provision. To such engineering problems the controlling factors, directly, or indirectly, will be space relations, and topographic configuration.

The densely settled states of Europe have, in the last fifty years, surveyed and resurveyed their areas, until experience has elevated the standard of their maps to that outlined above; and cadastral surveys, on much larger scales even, have been extended over thousands of square miles, at a cost per acre that, in this country, would, as a rule, be prohibitive.

In the past ten years several of our Eastern states have followed this abundant European precedent. Such minutely comprehensive presentation of geographic facts is a mark of advanced civilization; it is indispensable as a general convenience in a thickly populated country; yet its highest value would come if it were to precede dense settlement, and the intricate evolution of public works. During the progress of the topographic survey of Massachusetts, a statement was made before the Boston Society of Civil Engineers, by an engineer of the Boston and Albany road, that if such maps had been obtainable at the outset of railroad building in that State, their value in the avoidance of mistakes in general location alone would have been two millions.

The valley areas of California foot up about 33,000 square miles —four times the total area of Massachusetts. The cost of their survey would possibly be $200,000.00. The time required to do the work with thoroughness might reach six years. The expense annually would not exceed $35,000.00, and finished atlas sheets would be forthcoming at the rate of twenty or more a year.

But it is proposed that the State coöperate with the U. S. Geological Survey in this work, leaving its execution to that organization, and sharing equally in its cost.

Normally the map work of the Geological Survey is not on this large scale, and of this detailed character, but is adapted both in scale and degree of topographic detail to requirements for geologic representation. Exception has been made, however, in the Eastern States above mentioned —in Massachusetts, Rhode Island, Connecticut, and New Jersey, and, I believe, also recently in Pennsylvania and Maine; but these exceptions, and the finished State maps referred to, have been made at the request, and with the aid of the States themselves, to meet at the same time both their needs and those of the general government.

The Geological Survey has been engaged for a dozen years on the unprecedented task of mapping, in contours, three million square miles. Topographic maps are a prerequisite in geologic work. In the founding of this survey the several earlier organizations for exploration and surveys were merged into the present organization, and the present system and methods of the geographic branch are a development out of this inheritance of experience and training.

The great task of mapping the United States is proceeding with steadiness and despatch, yet, measured by the total of the area to be mapped, progress appears to be gradual. Also, following the lead of systematic geological investigation, rather than any symmetrical order of expansion, map work has been spread simultaneously from many widely-separated centers, ceasing for the time being in any region upon the completion of its special study. One of these regions, considered geologically as a unit, is that of the Sierras of California. Here there is actively under way, and has been under way for several years, an elaborate and detailed geologic investigation of the gold belt, so called; and here also, begun somewhat earlier and keeping a little ahead, topographic work is in progress. Of this survey of the Sierras, sixteen sheets are now finished, uniform in general plan and paper dimensions with those above described, but on a scale approximately one inch to two miles, or exactly $\frac{1}{125000}$, including nearly 1,000 square miles each, and with contour intervals of 100 feet. This smaller scale map work presumably will continue without interruption until the gold belt, and probably also the whole of the mountainous area of the State shall have been completely mapped; and this considerable work, according to a uniform and well-coördinated plan, may be finished within the next four or five years. But the valley and low foot-hill areas, economically the more important, will be omitted; or, if surveyed at all, will be surveyed upon the smaller scale, and with the larger contour interval, adequate for geologic purposes, but quite inadequate for economic purposes.

The larger scale would be double the present scale, and experience has shown that the cost also would be double; but the map area for any given ground area, would be four times greater, and the general usefulness would have a ratio greater by many times.

To summarize the case for this State: We recognize at the first thought of comparison, that California is topographically unlike the Eastern States referred to; it has a mountainous area of Alpine mas-

siveness and roughness, twice the size of all New England, and it has in addition a spread of agricultural lands four times the area of rock-encumbered Massachusetts, and not in scattered patches among hills, but in great valleys, one of them matchless in extent and promise. In the survey of the mountainous area the general government is at present actively engaged. The work is of the highest modern type; the scale is well adapted to the country, and no expense will attach to the State. Eventually, when Congress shall authorize publication, the atlas sheets, nearly 100 in number, may be had, presumably, at the cost of paper and printing—about five cents each. For the survey of the agricultural and habitable area, on the other hand, there is no present plan at Washington, and if there were, the resulting map, uniform with that for the mountains, would not meet the economic needs of the State, though meeting the needs of a geologic survey. It is thus seen that, unlike the Eastern States mentioned, it is not necessary to map the entire State on the inch-to-a-mile scale—that for about 125,000 square miles the smaller scale is sufficient; and that this work is now in progress and well advanced. For the more valuable one fifth remaining, however, a much more detailed map is needed. The precedents offered by the eastern seaboard states presumably might be followed here, and this more detailed map secured at half cost—the additional cost of the increased scale.

I have recently been requested by the State University to ascertain whether the geological survey would follow in California the New England precedent, if a like request and offer were to be made by this State. I am authorized by Prof. Thompson, Chief of the Western Division of Geography, to say that such a proposition would be favorably received.

REGULAR MEETING, APRIL 1st, 1892.

PROCEEDINGS.

MINUTES.

The meeting was called to order by the Vice-President, Mr. Luther Wagoner.

The minutes of the last regular meeting were read and approved.

The following new members, having been balloted for, were declared elected :

Andrew Fraser, Mechanical Engineer.....San Francisco, Cal.
Edward C. Jones, Engineer.....San Francisco, Cal.
Chas. David Marx, Professor Civil Engineering of the Leland Stanford, Jr., University.
Leon H. Taylor, Civil Engineer.....Long Valley, Cal.

The following names were proposed for membership and referred to the Board of Directors :

William H. Davenport, Irrigation Engineer, Visalia, Cal.; proposed by P. J. Flynn, Alfred Solano and Burr Bassell.

Robert Hall, Mechanical Engineer, of San Francisco; proposed by J. P. F. Kuhlmann, Otto von Geldern, and H. C. Behr.

W. O. Secor, City Engineer of Albuquerque, New Mexico; proposed by Luther Wagoner, Otto von Geldern and A. Lietz.

M. M. O'Shaughnessy, Civil Engineer of San Francisco; proposed by Otto von Geldern, Adolph Lietz and Geo. F. Schild.

Alexander Watson, Mechanical Engineer, of San Francisco; proposed by F. T. Newbery, C. E. Grunsky and Otto von Geldern.

A paper by D. E. Hughes, entitled, "The Sickle or Perfect Railway Curve," was presented, and announced by title.

The topical question of the evening was :

What is the Effect of Modern Brakes on the Railway Track, and its Permanent Structures?

The subject was opened for discussion by reading a communication from D. E. Hughes on the effect of the railway brake, and another by Alexander Watson on the methods of braking cars employed by street cable railways, wherein the author gave his opinion as to the efficiency of such brakes on the steeper grades of streets.

The discussion, however, took up the subject as relating to the modern *railway* brake only, the object being to determine if such effective devices, applied as occasions demand, may ever become elements of danger by injuries to the track, more particularly in curves and upon bridges, in as much as the energy of the train must be taken up by the rail and the underlying structures.

Messrs. W. G. Curtis, H. S. Wood, C. E. Grunsky and others participated in this discussion, which is published in the transactions.

Professor Willard D. Johnson, of the U. S. Geological Survey, addressed the Society, stating that a movement had been on foot to inaugurate an extensive topographical survey of the State, and that in order to carry out such useful and necessary work, it would require the aid and support of the professional engineer and the scientific societies. He explained at length the proposed method of making these surveys, the time that would be required to complete them, and the yearly appropriations necessary to cover the expenses of the topographers, who might be reasonably employed in such service for six years.

Upon motion it was ordered that the Society endorse the plan proposed by Professor Johnson, and to lend him its hearty coöperation in his endeavors to secure the approval of the authorities of the State; and that a committee of three be appointed to confer with Professor Johnson in effecting a plan of procedure.

The Chair appointed Messrs. Grunsky, Curtis and Vischer, and instructed them to call a meeting for the special purpose of agitating this question; to invite the officers of the State Mining Bureau, the professors of the Universities, the State and Federal officers interested, and the reporters of the principal newspapers, in order to create, at once, a public interest in this subject.

Adjourned. OTTO VON GELDERN, *Secretary*.

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME IX. No. 4.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

SILVER, ITS TRUE PLACE IN THE CIRCULATION.

An address delivered before the Society May 6th, 1892,

By J. W. TREADWELL,

Editor California Bankers' Magazine.

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This is not a political lecture, because the question is not an American question, but a question as wide as the world, embracing all people; nor is it a debate for arguing the question, but it is simply a review of the production of silver in the past eighteen years, and of its probable production in the next twenty years, and of the present position of such nations as use credit paper. If a survey were to be taken of all the nations of the earth, then the subject would be too vast for one lecture. Such a view has been taken as to show you those nations who are guilty of using credit paper which is not properly backed by coin (as shown in the diagram).

Many severe truths will have to be told, but simply in the best interest of the nations concerned. Any person wishing to dispute the statements made can write to the *California Bankers' Magazine* where the lecture will be published. The diagram shows, on a geometrical scale, the relative bulk of the credit paper, and the sound bank paper. The size of a twenty-dollar gold piece is given with the twenty pieces for which it exchanges, but the thirty pieces of silver which it can buy (equal to $30) are also shown.

The volume of silver produced by the world in 1873 is shown as 63,000,000 ounces, and the volume produced in 1890 as 132,000,000.

The total bulk produced in those eighteen years being 1,500,000,000 of silver, as shown; while the bulk of the world's probable production from now to 1910 A. D. is shown as a volume of 3,000,000,000 at the same ratio. This is the bulk of silver for which the world has to provide a use, and if the nations have found it so hard to deal with 1,500,000,000 in the last eighteen years, how will they deal with 3,000,000,000 ounces of silver in the next twenty years?

During the month of April 1892 repeated finds of a very heavy value have been made, the largest and most valuable being at the Broken Hills, in Australia, where a deposit of unknown size has been found, running 6,000 ounces of silver to the ton, besides lumps of pure silver. These mines have already given $22,000,000 silver in two years, and may be expected to give 20,000,000 a year to supply all India, China and Japan.

The reasons why such a great, steadily-growing yield of silver has arisen are:

(1) The silver is found in three wildernesses. The Rocky Mountain chain stretching from the north of British Columbia, down through Mexico, and in the Andes from Colombia to Tierra del Fuego.

(2) In the interior wilderness of Australia.

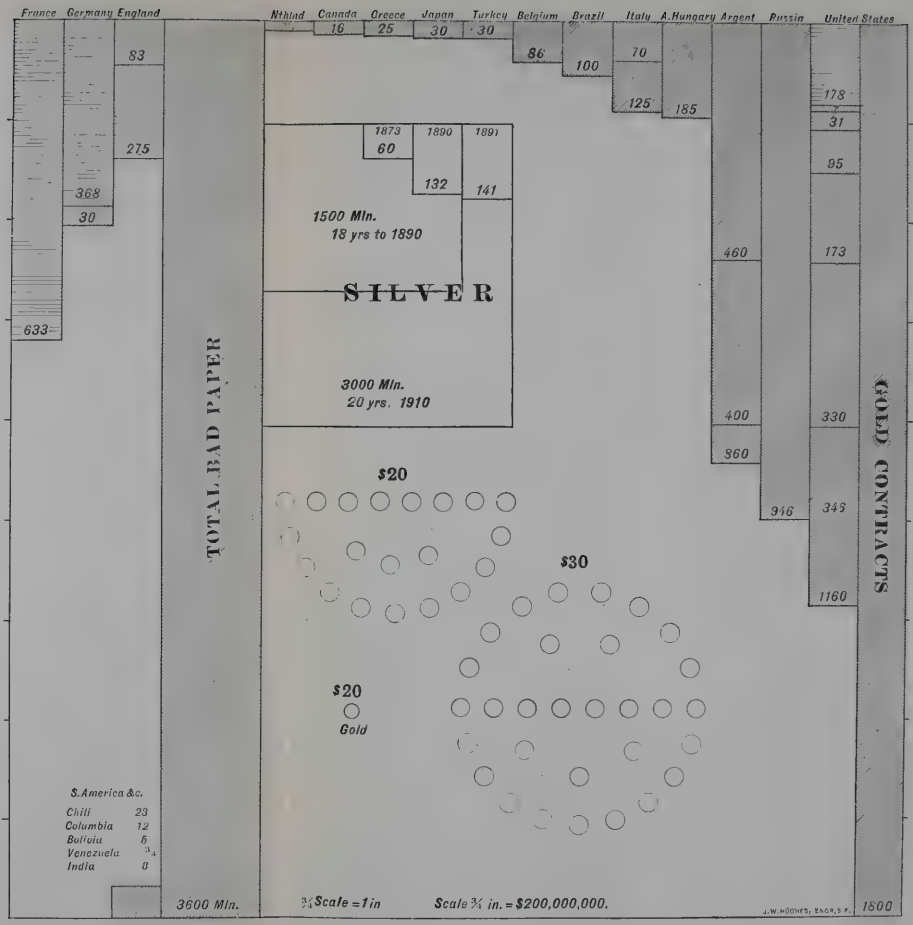
(3) In the newly-opened center of Africa.

(4) The people of the United States did not find the silver at first, because they only looked for it in the shape of galena or lead ore, 70 per cent. lead, and about $\frac{1}{10}$ of one ounce silver to the ton, and did not know that the richest silver ore is found in quite different shape, such as chloride of silver, light brown, (Here are samples lent to this lecture by the Academy of Sciences) sulphide of silver, black.

The adjoining diagram shows the volume of silver produced from 1873 to 1890, inclusive, $1,500,000,000, beginning with $62,000,000 in 1873, up to $132,000,000 in 1890, and the whole large square shows the volume of silver to be produced in the coming twenty years—to 1910 A. D., the first year, 1891, being $141,000,000, and the total $3,000,000,000.

The obliquely-crossed columns show credit paper badly based, or not based at all, like the $83,000,000 in the Bank of England. The European nations are represented at top—the South American at foot. The total bad paper is $3,600,000,000.

The columns crossed horizontally show good bank paper. One $20 gold piece is shown, and by its side the 30 silver dollars you can buy with it, while the 20 silver dollars for which it passes in exchange are shown above it.



It is a positive fact that during the overland immigration to California, in the forties and fifties, the wheels of the pioneer's wagons were passing along over the finest metal ores in Colorado. Had they stopped there, instead of going forward to die in the wilderness, they would have been rich. There are yet 1,000,000,000 acres of wilderness, to be searched in the districts above named, and the wealth of silver to be found is beyond count.

(5) There are new processes, such as the cyanide process and others, by which gold is now taken out of various kinds of ores, this gold was lost before; and no doubt the scientific men will repeat that in the refining of silver ores, as they already have so improved their processes, that the yield of silver from ore is getting steadily larger.

(6) The spread of population in the wildernesses of this world has increased the findings, and will still more do so. For instance, the enormous colony of British Columbia (stretching from 49 degrees latitude to 60 degrees, and covering meridians from 115 degrees west to 140 degrees, larger than California, Washington, Oregon, Idaho and Nevada) is destined to be a mighty empire, and its mountains (when settled by people) will be found full of money metals for them.

(7) The last and greatest reason is the new means of cheap carriage by electricity, the railways of the 19th century are already obsolete, and the rivers of the Rockies turned into electricity will carry the ores to market in single carloads more cheaply than ever before, on light and cheap roads and bridges.

In the face of this wonderful bringing forth of silver from the world's wastes, a proposal is brought before the nations that the United States shall coin silver freely for all the world at 50 per cent. more than its market value, that is, that a silver dollar costing 65 cents (see diagram) shall be stamped and passed at 100 cents; also that the nations of the earth shall be invited at Chicago to do the same. Mr. S. Dana Horton has even gone farther and has proposed that all the banks in the world shall be forced to use silver at 50 per cent. more than its market value, that is, bankers are to be forced to give 129 cents for 86 cents' worth of silver, or an advance of 43 cents per ounce upon its selling price today.

This proposal was even submitted in the American Bankers Association, and is strongly pleaded for by him in a book of his called "Silver in Europe," under the chapter "Parity of moneys." When we reflect that this same Professor S. Dana Horton has been selected by our U. S. Government to travel through all the nations of

Europe, for the past three years, in order to push into their notice the above piece of tyranny upon bankers, surely it is time that we began to ask: "What is the true place of silver in the circulation?" The free coinage of silver at 50 per cent. more than its market value may be shown to be folly on three grounds:

(1) Free coinage *without the law of parity* (parity means redemption of silver in gold) has been tried and is now in practice in India, and in Mexico, and China. It lowers the value of the coins to bullion price at once, and drives gold out of those countries. In India the silver rupee, formerly worth 24 pence, is now only worth 15 pence; and because the debts of India are due to foreigners in gold the Hindoos are forced to pay 24 pence in gold for each rupee of debt, that is a premium of about 60 per cent. on all the principal and interest of their debt. They are forced to take silver rupees for their crops, and so lose forty per cent. of the value of all their produce, while that also lowers the price paid for our American wheat in the central market in England. The Hindoos have addressed a remonstrance, in April 1892, to the Imperial Government asking them to take up the silver question.

In Mexico the silver dollar only buys its bullion value, and all prices and wages are lower than in the United States, see the excellent articles by the Mexican Minister in that admirable magazine the *North American Review*. In China the Government mints stamp bars of silver, from which the buyer of goods cuts off a piece by the Haikwan (customs) tael weight, which piece passes for goods at its daily bullion value. This is the same in effect as free coinage without the law of parity.

As many of the contracts in the United States of America are silver contracts, it follows that because the passing of an open free coinage law would drive down the value of silver to market price, therefore such a law would be declared void by the U. S. Supreme Court on the ground that it impaired the obligation of existing contracts, and so was unconstitutional.

2. Free coinage of silver with the law of parity has nowhere been tried, because if it were tried it stands to reason that every body who had silver would at once exchange it for gold, and that all the silver in the world would come to the United States of America, even the Hindoos would gladly sell their 15 pence rupees of silver for 24 penny gold rupees, and put an end to their troubles, but where could the gold be got to redeem all the silver in the world? That is the problem.

In the states of the Latin Union, where silver is legal tender, the moment that silver fell below par, the free coinage of silver was forced to stop. The notes of the Bank of France are silver notes, payable in silver, and only paid in gold at the option of the bank, and then at a premium of 2½ per thousand. It is that fact which forces the silver into circulation in France, because people must use silver, whether they like it or not; at the same time the forcing out of the silver by that great bank causes the gold stock to be always increasing, because the use of silver gains the gold. The Bank of France is even able to take and hold 500,000,000 francs of other Latin Union silver, because the other members of the Latin Union use legal tender paper, and so drive their own silver out of their own countries, having replaced it with fiat paper, or credit.

3. Free coinage of silver, if enforced by legal tender, would be declared unconstitutional also, because it is against Article I, Clause 10, of the Constitution, which forbids the impairing of contracts. If free coinage with or without the law of parity be impossible, how then can we use silver at all? Before answering that question, we must first ask another; Is there any cause for the fall of silver other than over production?

Yes! There are four great causes, which are:

(1) The use of false credit paper by many nations.

(2) The paternal system of *political banking*.

(3) The abandonment of silver by European politicians.

(4) The utter absence of all control by the bankers.

These statements of fact refer to all the nations of the world, not to the United States alone, and you will please to so read them. They will be proved by the diagram attached, which shows at a glance who are the nations guilty of using credit paper.

The first statement proved by the diagram is: "The use of false paper by many nations," and in the consideration of the immense volume of about 3,600 millions of credit paper, it is as well to begin with the smallest of the issues, and to rise steadily to the largest user of paper, that is, the United States of America.

The leading example of credit paper, which has had such a power to make other nations follow in its track, is the Bank of England. It may seem to some minds an invidious thing to attack the financial laws upon which the Bank of England is founded, but banking truth is the one thing that we are here to find, no matter what the cost may be.

The Bank of England is founded upon credit paper instead of upon tangible securities, or upon convertible assets. A bargain was made between the Bank and the British Government, that in consideration of the Bank lending £16,250,000 ($83,000,000) to the British Government, at 3 per cent. interest, the bank should receive the privilege of issuing notes upon nothing but credit. There was no banking necessity for any such arrangement. It would have been better and safer if the Bank of England had taken the $83,000,000 in gold, and had lent it to bankers only on securities deposited, thus gaining a live two-fold security (viz., that of the borrowing bank, and that of the tangible securities deposited), instead of burying all that gold in a public debt, and taxing the people of England 3 per cent. per annum, in order to pay interest on the gold spent by the government.

There would also be this very great difference, that the $83,000,000 of gold would be continually used by all the bankers of London to promote trade and industry, instead of being absolutely NO WHERE AT ALL, having been spent by the government, which owes now $3,500,000,000, while the gross amount of the annual value of property and profits assessed for income tax is only $3,100,000,000, or $400,000,000 less than its debt. The practical value of this great national credit was tested the other day, when in the Baring failure it became necessary to get at once $25,000,000 in gold in order to keep the Bank's gold reserve to its legal height. The whole power and wealth of the British Empire of 360,000,000 souls were not able to furnish that gold when it was wanted; but England was forced to go to France and to Russia for the money. What was the worth to the Bank of England of that great debt of $83,000,000 due by the British Government? *In gold, absolutely nothing at all!* Whereas, if that gold were loaned on tangible securities, as explained, there would be a visible and realizable value in hand.

The Bank of England then is founded on false financial laws, and should be chartered upon a wiser and safer basis. But observe the world wide effect of the bad example of founding notes upon a debt, and issuing credit paper.

The nations one after another were led by the politicians to believe that there was nothing equal to the system of the Bank of England, and they set to work to see how they could copy it and improve upon it. Sturdy Holland, generally called Netherlands,

issued $7,500,000 credit paper straight, and following the diagram we make this list.

	Credit Paper.	Population.
India	$8,000,000	220,000,000
Netherlands	7,500,000	4,500,000
Canada	16,000,000	5,000,000
Greece	25,000,000	2,200,000
Japan	30,000,000	39,000,000
Turkey	30,000,000	22,000,000
South Am., Chili, (27); Col. (4); Bol. (12)	40,000,000	8,000,000
Belgium	86,000,000	6,000,000
German Empire, R. K. S.	30,000,000	49,000,000
Brazil	100,000,000	14,000,000
Italy, (70–125)	195,000,000	40,500,000
Austria-Hungary	385,000,000	40,000,000
Argentine	860,000,000	4,000,000
Russia	946,000,000	113,000,000
	$2,758,000,000	
United States	1,000,000,000	64,000,000
	$3,758,000,000	

Time will not allow a history and analysis of each of these items, but a few instances will suffice to show the folly, from a banking point of view, of these credit papers. In the earlier part of this lecture India was seen as very sorely troubled with $900,000,000 bad silver, by the fall in the value of silver, making a loss of 60 per cent. in the payment of yearly tribute and interest to Europe. Yet by the issuing of credit paper, $8,000,000, (for which there is no necessity whatever), the Indian Government displaces that amount of silver with paper, and so helps to create the very financial disease under which she suffers.

The proposition which is to be proved is: "That the use of credit paper by the nations drives silver out and destroys its value."

Then take the little country of Greece, just struggling into existence with a population of 2,200,000 only, the public debt is $125,000,000, and is due in gold, so that in order to remit the interest, it becomes necessary to buy gold at a very heavy discount, giving D 200 for D 100.

Thus, by discrediting silver, Greece has to pay a heavy tax yearly, but if she taxed herself, once for all, to redeem the credit paper, the Greeks could have a bank on the principle of the Bank of France, and by using silver would at once raise paper to par.

Take Turkey, where $30,000,000 of credit paper was issued, and in the impecunious state of the Turkish Treasury the paper was

simply abandoned to the holders; that is, those who were foolish enough to take it, were robbed to that amount, just as has already happened in the United States in early days with the Continental notes, when $200,000,000 were stolen from the people by the politicians.

In the case of Belgium, which has a population of 6,000,000, they hold only $21,000,000 against an issue of $107,000,000, and by such an over issue have driven 320,000,000 francs of their own silver out of circulation, and 200 millions of this silver is now in the Bank of France waiting to find a purchaser, and causing a depreciation of the whole volume of silver in both Belgium and in France and in the world, while if a war arose between Germany and France, and the theatre of war should shift to Belgium, then her $86,000,000 of credit paper, would show their worthlessness, and to the ruin of war would be added commercial and industrial destruction.

Brazil is another instance of a country, which produces a large amount of gold yearly, yet all that gold is driven out of the country by a false paper issue of $100,000,000, which is the cause of endless poverty and distress to the people of the country, while if they used their own gold as a currency, or to buy silver in order to back their paper through a properly founded bank, the profit would arise not only in the use of the silver, but in the raising of all the money to par, and so making great savings at the exchanges.

The other South American countries which discredit silver are all silver-producing countries, and they do their utmost to debase the value of their own produce by using credit paper. Thus Bolivia has produced 30 millions of silver in three years, and complains that all that silver leaves the country, though the cause is plain enough in the $5,000,000 of false credit paper which is thrust upon the people as legal tender.

Colombia, which is a heavy producer of gold and of silver, has forced legal paper of $12,000,000 circulating at a discount of 50 per cent., which really causes them to pay double interest and double the amount of the debt, while the driving out of the silver produced in the country causes a dead loss to the miners of half the value of their labor.

Chili, a silver-producing country to a very large amount, has also issued $23,000,000 of credit paper, which displaces silver from the circulation, is an element of weakness, and kills the product of the silver mines. Venezuela follows the same plan, with the same results in a small way.

These countries are only the little sinners, we must now turn to the

greater countries. Italy, troubled with repeated deficits, (through the ambition of her politicians) helps to increase her own deficits, and to further impoverish her people by an issue of $70,000,000 credit paper, and $125,000,000 of surplus bad issue through the banks. The effect has been to drive her silver five franc pieces out of Italy into France. Although bound to redeem that silver in gold by the Latin Union, yet Italy is unable to fulfill her contract.

Austria-Hungary has issued $385,000,000 of forced paper, and instead of copying France by founding a silver note, is discrediting silver by proposing to sell it and to go upon a gold basis, the produce of her own mines being about $7,000,000 in three years, and the loss thus falling upon the unfortunate people in three ways :

(1) The depreciated paper florins.

(2) The cost of the new loan in order to buy the gold needed.

(3) The permanent loss of revenue to the silver miners, and to all commerce.

Argentine is the greatest of all the enemies of silver, although also a producer of the metal. Paper debt has been issued on the land to the value of $534,000,000, and a large issue of credit paper, based upon paper bonds and not redeemable in gold, has been issued to the unfortunate people to the amount of $380,000,000. The whole population only number 4,000,000, and it is quite hopeless to think that they can ever redeem about $1,000,000,000 of debt. The purchase of a large piece of territory by the Jews, and its colonization under Baron Hirsch, will probably lead to a new monetary system being adopted eventually. The house of Barings were criminally responsible for assisting to create such a load of debt to foreigners upon the shoulders of a poor people robbed by politicians.

The effect of raising silver to par would be to help their mines, and if (as was reported) they have bought silver to back their notes, that would be the road toward redemption. It would need very heavy taxation to supply enough silver to pay their liabilities, but a great increase of population would lighten that taxation, and sales of the lands to the new settlers would also form a redemption fund.

Russia is the next upon the list with $946,000,000 of legal tender paper, which, like the U. S. greenbacks, is forbidden to be redeemed by law, and which could not be redeemed if desired, and the Czar has just ordered 100 millions more to be issued. The notes, of course, are utterly useless outside of Russia except at a very heavy discount, and in Russia itself they only pass at 60 per cent. of their

face value, so that a rouble's worth of work only buys about half its value of bread. These paper roubles are the counterpart of our American Continental currency, and will most probably share the same fate: viz., repudiation and robbery. How do the Russians keep their loans afloat in foreign countries? Just as our U. S. Treasury does, that is "*by manipulating a central gold balance.*" Thus the wretched people are forbidden to bring silver or paper roubles to the Treasury, and they have to buy gold at a heavy premium to pay taxes. The gold mines belong to the Czar, and their produce is hidden from public knowledge. The Czar raises gold loans in Europe and converts them when they become due, leaving large gold balances in the banks of the capitals of Europe to liquidate the interest. It was in that way that the Bank of England was enabled to borrow gold from Russia by being allowed the use of some of Russia's borrowed gold for a few months. It was reported in the papers that Alphonse de Rothschild, in Paris, had his vaults full of millions of Russian bonds. If so, he is very unwise, for let us imagine that the misery and nihilism, which are the result of legal tender, debased paper, should so far succeed in revolt as to kill the imperial family in a day and deliver the Imperial Bank of Russia (which is only a name for the Imperial Treasury) to the people; then, when the $209,000,000 of the central gold balance are gone, and the country has nothing but 1,000 millions of legal tender paper, what sort of a revolution would arise? Bonds, loans, paper, people involved in one common anarchy would sweep all civilization to destruction. Russia has absolutely no money at all, and Alphonse de Rothschild would soon find it out to his lasting sorrow. Argentine was bad enough. Russia will be worse.

The German Empire is not without fault. The Reich has been guilty of issuing $30,000,000 of faith and credit paper, legal tender, called Reichs Kassen Scheine. There is no necessity for it, it displaces just that volume of silver, and so helps to drive down the price of the thaler and the mark, and to punish the Germans. The sooner they repent of their folly, tax themselves, and pay it in silver, the better.

So we have passed through $2,458,000,000 of false paper, and before entering our own country, the United States of America, it will be well to ask a few plain questions.

First. Of what use would it be for all these wretched nations to try to back that paper with gold?

The problem is: "Wanted, $2,000,000,000 gold at once," where

is it? How long will it take to mine it? Yet the politicians in all these European lands, forgetting all the results of their past stupidity, utterly ignorant of all the laws of finance or banking, propose to enter upon a fight for the world's gold. Led into the snare by England, the voices echo across the world from London, as from Rome, from Amsterdam or Brussels, from Wien or Buda Pesth, as from Berlin or Athens, "Let us buy gold?" Suppose they bought the gold, where would they get the cash to pay for that 2,000 millions? It must be bought with taxes.

It is not so much the lack of gold as the superabundance of debased paper that is the disease, and in any case much of that must be extinguished forever. Paper that has not got behind it coin or visible assets, realizable in coin, is only a printed lie. That is why the $83,000,000 of Bank of England notes is really a false legal tender currency, and the first cause of all this trouble in the world.

The second question is "Of what use would it be to give to each of these nations the privilege of free coinage at a false value of all the silver, which private individuals might offer to the mint?" Foreigners could then bring, to the mints, silver bought at 65 cents on the dollar, and receive it again from the mint stamped as worth 100 cents, and so plunder the unfortunate people of 50 per cent. profit upon all the silver so treated. What would happen to the silver? It also, as it has already been in Italy, Belgium, Greece, etc., would be driven out of each country by the legal tender paper under the Gresham Law. So the evil would be worse than before, because the people, after being robbed by foreigners of 50 per cent. value in the silver, would be left with the legal tender paper on hand, poorer still than before.

The whole of the robbery, which goes on every day through this debased paper, is chargeable to the fact that the politicians have appropriated the business of the bankers. What do the people know of the mysteries of finance? Are our representatives in Congress better informed? If so, why have the above facts not been shown forth? I am the first man to do it.

Turn to a banking country now, where these great truths are put into practice. France, the silver country of the world, although she produces no silver to speak of (*i. e.* only about $3,000,000 per year) yet by good banking, she is able to use a bank note, which is nothing but a silver note, payable only in silver, and by using that silver note she steadily gains gold all the time.

Cast your eye backward through this dying Nineteenth Age of Christ. In 1803 you see Napoleon the Great, founding the Bank of France, and she shines through his prosperity, when he returns with his broken legions from Moscow, and thence passes to the ruin of Elba, the Bank of France lives on. The Bourbons cross her track, and Waterloo crashes past; she passes on through all, and through the Orleanist régime too; she goes through the change into a republic, and survives the Coup d'Etat, and even the Little Napoleon. Sedan, and the German indemnity of $1,000,000,000 roll over her head, as also does the Commune, and still the Bank of France keeps on, while at the close of this passing Age see how her position contrasts with that of the British Empire.

In the Indian empire they have free coinage there of $900,000,000 of silver rupees, which circulate at a discount of $400,000,000, representing therefore only a value of $500,000,000 in actual purchasing power, because there is no central bank to make the circulation fit into gold values.

In France, without free coinage of silver, there are $700,000,000 of silver in circulation, which circulates at its full value, because by the banking power of the Bank of France, with its 258 banking places, this silver is always convertible into gold at 2½ per thousand (Moxon p. 50), although its face value shows a discount *at market price* of one third, or $235,000,000. Such is the immense power of sound banking, and of a sound note issue, based on silver, payable in silver, and so forcing the silver into circulation.

While in India, with free coinage of silver, enormous losses have to be made in order to purchase gold with debased silver for remittance abroad, because there is no central bank, embracing the whole land in its arms, and keeping silver up to par; in France no losses arise, and she, who has no free coinage of silver, and no silver corner like the United States of America, is the only friend of silver in the world, and the only country which keeps silver at par and in circulation.

What is the only lawful judgment to be drawn from these two cases, where such utterly opposite laws and such utterly opposite results prevail? Is it not that free coinage is folly; that all mankind should abolish the system of political banking, and should establish in each land a system of banking which will surely bring forth such work as that of the Bank of France, and so will bring silver back to its old place, and to the value that it had in olden times?

That free coinage of silver is an utter failure and brings ruin in its train is seen in India. That true banking, without free coinage of silver, can make and keep a nation prosperous, hold silver at par, and even pay a German war indemnity without trouble is seen in France. That is the lesson of this Nineteenth Century.

Now let us turn to the worst enemy of silver in the world, that is, the United States of America; the greatest example of the "*paternal system of political banking*."

First. I stand right here upon the constitution of the United States; and I declare, with Justice Field of the Supreme Court, that the issue of $346,000,000 of legal tender paper is a breach of all our liberties; because under the Constitution the United States has no power to emit bills of credit, but only "to coin money and to regulate the value thereof," (that is value of coin). Congress has no power to regulate the value of paper so as to make it legal tender, but only to regulate all the value of the money coined. It is true that in the comment (p. 6) upon the Constitution, the following words are added, as from the case of Lick *vs.* Faulkner, 25 Cal., 404: "The United States Constitution confers upon Congress the power "to issue Treasury notes, or bills of credit, *not in express terms*, but "as a power *necessarily implied*, and also to make such notes or bills "a legal tender in payment of debts."

The word *imply*, a Latin word, means to fill in or *to twist in*, and if lawyers are going to exercise their infernal arts to twist powers into Congress, that are not conferred *in express terms* by the Constitution; then Farewell Liberty! Welcome tyranny and destruction!

Hon. Jno. Jay Knox says, (U. S. Notes, p. 10): "At the close "of the war with Great Britain the minds of all classes were imbued "with a wholesome antipathy to paper money, and as a consequence, "when the Federal Constitution was under consideration, the power "to emit bills, (which, in the original draft was given to the United "States), was stricken out."

Clause 10, Art. 1, forbids the individual states to emit "bills of "credit, or to make anything but gold and silver coin legal tender "in payment of debts, or to impair the obligation of contracts."

If this clause had been strictly followed, then the States would have been forbidden to do by their deputies, the state banks, those things (viz: the issue of wild cat state notes) which they are not allowed by the Constitution to do themselves. Then all these robberies of hundreds of millions, taken by the wild cat and red dog note issues of the state banks from the people of the United States, would have been prevented.

The history of paper money in the United States is too long a subject for this lecture; but before the present Constitution was adopted in 1787, the Continental Congress in 1775 had already forced the issue of $242,000,000 bills of credit, called Continental notes, which ended in a robbery of the people of $196,000,000 (see J. J. Knox, p. 10), and the terrible ruin and loss brought upon the people by these notes, caused the founders of the Constitution in the twelfth year of the independence of America to forbid credit paper. That sin has been stereotyped into our life. If a man despises anything, he says "it is not worth a continental."

Second.—The rule of construction for the United States Constitution is found in Amendment X, thus:

"The powers not delegated to the United States by the Constitution, nor prohibited by the Constitution to the States are reserved to the States, or to the people."

Now as the power to emit bills of credit was not delegated to the Congress by the Constitution, but only the power to coin metal and to regulate metal values, it follows that all legal tender paper is illegal, unless the people amend to allow it.

Leaving the law and turning to history, what do we find? That the issue of the greenbacks robbed the soldiers in the field of two thirds of their pay. Yes, indeed, those very greenbacks that we are passing from hand to hand today have done this dirty work; more still, they have ruined hundreds by their fluctuations, and hundreds have made fortunes by gambling in the paper bills, and in the gold premium which they caused.

All these crimes and robberies are laid at the doors of the bankers by ignorant persons, who do not understand that it was the politicians, who by stealing the duties and privileges of bankers, undertook to issue sham bank notes without coin backing.

Every bank note has its whole value at its back, one part in coin, and the rest in visible and realizable securities. If it be not so provided, it is a sham bank note. Most of these issues of the United States are sham bank notes, which no bank would dare to issue, because they have not their whole value behind them in coin and in assets.

There are eight kinds of paper now floating in the United States, as shown in the diagram, and it is easy to prove that this credit paper is the real cause for the depreciation of silver.

(1) Gold certificates, $178,000,000. These are Treasury receipts for gold, exempt from taxation, and consist of the last gold reserves

of the bankers, they are legal tender to the customs, but they are *not legal tender* between citizens, they are used illegally, that is without any lawful authority, by the national banks as lawful reserves (see Treasurer Upton, p. 264).

Bankers are partly driven to use these by the monstrous system of taxing the cash in the banks for State purposes, instead of taxing the income of the banks only ; in a right system of taxation and of banking they would not need them at all, but would use the gold reserve system of the Bank of England which is better.

(2) Currency certificates, $31,000,000 These are created under the Act, 8 June 1873, and are Treasury receipts for deposited greenbacks of small denominations (Upton 262), they are used at the clearing house in payment of balances. They are full legal tender.

(3) Silver certificates. These are Treasury deposit receipts for silver dollars, $330,000,000, they are legal tender to the United States of America, but are not legal tender between citizens. The dollars have fallen to $220,000,000 in value.

(4) Treasury notes of July 14, 1890, $95,000,000. These are warehouse receipts for the bullion in the silver corner at Washington, and are an original invention of John Sherman, differing from all paper in the world, because, though based upon silver, they are payable in gold, and they are gaining at the rate of $4,500,000 paper per month. They will soon be the overmastering element in the Treasury, because they are legal tender for all public and private dues.

(5) Greenbacks, or United States notes, $346,000,000. These are the legal tender paper notes upon which the great decision of the Supreme Court, referred to above, was given, and from which, with Justice Stephen J. Field, I take the freedom to dissent on the grounds already given. They were issued in the war, and are said to be a full legal tender for all debts, public and private. The Treasurer is forbidden by law to redeem any of these notes, and is ordered to pay them out as fast as he receives them, and to replace all worn notes with new notes of the same denominations.

(6) National bank notes, $173,000,000. These are notes based upon paper bonds, deposited with the Comptroller of Currency, and are legal tender between citizens but are *not legal tender* to the customs.

(7) Old state bank notes, $100,000. Out of the wreck of the state wildcat banks and red dog banks there still remain some notes outstanding unpaid, but these it is needless to say are not legal

tender to anybody. The gamblers in banking (after wrecking their banks) could buy up their own notes by the sackful and escape punishment for their crimes, such is the history of our credit paper in the United States of America.

(8) Fractional currency, $7,000,000. That is all that is outstanding of the paper issued to replace subsidiary silver, another of those insane experiments in banking with credit paper which brought loss to the United States of America.

(9) The specific contract law, $1,840,000,000. No statistics can be compiled of this private currency which overrides and expels all the currencies of the United States of America, and demands that, whatever the money used by law may be, these papers shall only be redeemed in gold. It may be best to begin the description of the banking effect of these nine kinds of credit paper from the last to the first.

Senator Stewart, being the greatest enemy of silver in the world, (that is the person who has done the most to depreciate its value) gives us a good example of the gold contract currency, by his having registered about twenty-six of these gold contracts in Alameda, Cal. On the diagram these credit papers are indicated. They are vicious credit paper, the reason for that may be shown thus:

Suppose that the efforts to lower the standard silver dollar to bullion value by free coinage, as in India, be successful, then the debtors who signed this gold bug currency (as it is called) would have to get $200 worth of silver in order to pay their creditors $100 worth of gold under their contracts. The creditors would thus double the value of all their wealth. So the gold contract is really a very bad paper currency for the United States of America.

There is no other part of the world where such a currency prevails, and it will be clear that its *raison d' ètre* in the United States is because the whole body of legislation in this country is against silver through the crowding out of that metal by credit paper, as will now be proved. Sweep away the credit paper, the gold contract will die.

The next item in credit paper is No. 8, $7,000,000 fractional currency. This was issued during the war to raise money, and its effect was to drive out the subsidiary silver, mostly into Mexico and Canada, where our half dollars, quarters and dimes passed at their bullion value, being driven out by Gresham's Law, that the bad (paper) replaces the good (silver). Notice now, when redemption came, the Canadians and Mexicans sent in these millions of sil-

ver and received their face value from the Treasury, making an enormous profit out of Americans by collecting the difference between the bullion value at which they bought them and the face value at which they sold them. So again the politicians plundered the people of the United States of America of millions of dollars, because they had undertaken the banking business of which they were totally ignorant.

The old state bank notes, No. 7, total $100,000. These have been already dealt with, all that is needed to say is : "Let the people of the United States of America be warned against the proposal of Congressman Harter, of Ohio, to repeal the ten per cent. Federal tax by which this vile credit paper was finally extinguished. If the question of the power of the states to charter institutions to emit bills of credit (which the states themselves are forbidden to do by the Constitution) should ever come before the judges then, most probably, some tricky lawyer would gain a judgment against the Constitution of the United States of America upon the ground of *powers necessarily implied*, and so once more the lawyers would *justify the wicked for a bribe*, as the good book says. Let us put our foot down for nothing but a United States note backed by coin, redeemable everywhere, and with three-fold security.

Next in order comes No. 6. National bank notes, $173,000,000. This is another form of bad credit paper, because they are based upon United States paper bonds, and although used as a war measure, they have no place in times of peace, for they should and could be based upon silver and gold only. To show the weakness, let us suppose that a labor war should arise in the United States, and what would be the price of those $175,000,000 of bonds? Probably as in the former Civil War, 35 per cent., or only $58,000,000. Now according to the national bank law, our Comptroller of the Currency could call upon the national banks to deposit further security—$116,000,000. That would mean one of two things, either the national banks must at once surrender all their notes and all their bonds or go bankrupt, one and all. This shows the folly of credit paper not based upon silver or gold; and remember that this $173,000,000 paper just drives out that volume of silver, or partly so, and really is one of the greatest causes of the present low price of silver.

If you use silver it will rise; throw it out of demand and silver falls. Observe that is the law all the way through.

Our national bank system is an admirable system. It should embrace all the banks for commercial purposes in the United States of America; and it can be made to do so if the principles of the Bank of France be followed, and a true silver note be issued, payable only in silver, which would cause the circulation of the great hoard of white metal now imprisoned by the political bankers in Washington.

The next item is the United States note. No. 5, of $346,000,000. The nature of these notes has been explained, and by the laws of plain common sense, they have no right to exist, because they are a credit paper, expressly made forced legal tender by law, and expressly forbidden by law to be redeemed. The ruin and misery that these same notes have caused to the people of the United States of America, are well known to you, but as this lecture is to go to the nations of the world, it will be as well to sum the disasters brought on by these notes.

(1.) They were issued to avoid raising gold loans, and it must be clear that if gold loans had been raised in their place, the cash would have been brought into the United States of America, and the people would have drawn upon foreigners for wealth, to be repaid by the prosperity of future years. Instead of gold, these credit papers were paid away to the poor soldiers, bleeding and wounded upon the field of battle, and the heroes were swindled by paper out of two thirds of their wages. Then the government in buying from traders the supplies needed for war, could only buy $100 of value by paying $300 of paper for the goods, so that the permanent debt was made larger every time this *accursed credit paper* worked its mischief at the exchanges. The war thus was made to cost hundreds of millions more than it otherwise would have done, and we suffer now the penalty of issuing credit paper and of not raising gold by bonds.

It also led to furious gambling. Gold boards were founded. There large sections of the money gamblers spent their days speculating in greenbacks and in gold.

At this present day there are to be found ignorant people who blame all this on the bankers. It is Congress that should bear the scandal. The politicians who made these infamous greenbacks. They float around silently, breathing out their dreadful story of veterans robbed of their pay, citizens ruined in the gambling hells and plundered by speculators. If these greenbacks could but talk, what a tale of ruin, misery, horror, despair, suicide, and broken hearts they would tell. Such in all ages is the story, when politicians set them-

selves up as bankers, and issue credit paper unbacked by coin, instead of a true bank note.

France, with her silver bank note, passed through worse stress than the United States of America, paid a worse indemnity, because *she would not let the politicians do the banking*. Are these bitter lessons to be wasted? Look ahead! If a civil war or any war should come, what will be the value of these greenbacks, these bills of credit emitted against our Constitution? They would fall, and in falling would carry down the millions of people, who hold them, into ruin and disgrace, into despair and death, as they did before.

These notes drive out a volume of $350,000,000 of silver, which should and could take their place, for by the Gresham Law it must be so. Everybody will pay away greenbacks (if he has a suspicion that they are going to be bad), and keep silver, but whether or no, the business, which these paper notes do, would be done by silver, or by silver notes, if a central bank issued them, through a federation of all the bankers, and the increased demand for silver again would raise its value, while the dollars would be forced out of the Treasury into the circulation, if the politicians were turned out of the banking business.

The Treasury note comes next. No. 4, $95,000,000. This is a financial curiosity, a banking *lusus naturæ*, the child of John Sherman's brain, and Hon. R. P. Bland's pet, till silver fell.

The Treasury does not buy silver at all, it issues warehouse receipts for six wagon loads of bar silver every working day of the year, but these warehouse receipts are legal tender for all dues, public and private, and are redeemable in gold. If they were not redeemable in gold, they would only be worth bullion value, and already these warehouse receipts represent a larger value than the silver bought with them. They are a more dangerous currency than the greenbacks, and if allowed to grow to $600,000,000 in ten years, with the immensely increasing yield of silver, they will throw the whole country off the present standard, because the Treasury follows the Russian finance in keeping a small gold balance, by which outside exchanges can be made in gold, while all internal exchanges are mostly in credit paper.

The very same silver, used on banking principles by bankers, could float a much larger note issue safely, because the paper would be backed by 100 per cent., one portion of which only would be coin, and the rest visible and convertible securities, bearing interest.

This shows that, when politicians play at banking they cannot make the money go so far as a banker can, because he lifts profit and makes exchanges, promotes industry, and makes a larger use of the same volume of cash, while forcing silver into circulation.

Silver certificates, No. 3, come next.—$330,000,000. This is really a savings bank, in which the depositors get no interest for their money. What a loss to the United States that such an immense quantity of standard silver dollars should be oxidizing in the vaults of our Treasury and making no interest either for the depositors or for the holders, but costing the country a large sum for yearly care, and for the cost of certificates and book keeping. What will be said in London, Paris, Berlin, Rome, and all the capitals of Europe, when they read in this lecture that the United States is so rich that it can afford to throw aside such an enormous amount of wealth for absolutely no purpose at all? When they learn further, that the deposit receipts are *not legal tender* between citizens at all, but are only legal tender to the Treasury for public dues?

This is the most complete destruction of all the rules of banking, that ever was seen in the world, and will be a lasting wonder to future generations.

The law of banking has never been better stated than in the well known words: "Why did you not pay my silver into the bankers, that when I came home I might collect the deposit receipt with the interest?" These dollars might as well be wrapt up in a napkin, as the fool did with his, and buried in a hole in the ground for all the good they do.

If I had the power in this matter I would make a proposal, which, though it may startle you, will not, I trust, be found fault with. It is a simple business proposition. I would take 100,000,000 of these idle silver dollars and build the Nicaragua Canal with them, charging 5 per cent. interest on the loan, and 5 per cent. commission for discounting the bonds. I would place the whole $100,000,000 of Nicaragua Canal bonds in the Treasury, and also the $70,000,000 of Canal stock offered by the company as collateral, and thus having the canal built under the supervision of our engineers, and the stock, as fast as it was subscribed being paid off the bonds, I would make the loan secure and build the canal.

Thus the idle dollars, which have fallen in value $110,000,000 since they were paid in, would be turned to safe and profitable use, and the United States would have the honor of building the canal, without breaking the Clayton-Bulwer Treaty in any shape or form.

All that would be necessary would be a short Empowering Bill and amendment to the Act of the Silver Certificates, in order to enable the work to go through at once. So California would have the honor of having found the money to build the canal by simply using the hundreds of millions of idle dollars lying in the Treasury.

That is the method by which bankers make money. They take deposits like these $330,000,000 and keep the reserve to pay the moving demands, they then put out the balance in loans on stocks, bonds, etc., and thus they earn the interest of which the Master spoke.

It is the greatest of all follies for a state to undertake paternalism, and this leads to the second cause for the fall of silver, that is, "The paternal system of political banking." All these great banking crimes arise just there, unscrupulous politicians in all the nations of Europe and in the United States of America want to finger the cash, to make places for their relatives and friends; they then undertake to issue credit paper based upon nothing, persuading the unfortunate people that it will be for their good.

When this credit paper is first issued it causes an enormous prosperity, then the politicians pick up the plunder. Bye and bye the day of reckoning comes, it has to be paid and there is no cash, or only a small portion, to pay it, the paper falls, everybody is ruined, and they all damn the bankers, who have had nothing whatever to do with it.

Reasoning with an American on the folly of issuing greenbacks, he said: "But we make interest on that $240,000,000." No, you do not; a properly banked money earns interest and advances trade. Thus if these greenbacks were replaced with a true silver note, the Central Bank would be lending millions to trade and farmers, through the western banks; but you stand exposed to be blown up by a financial cyclone by these very credit papers. If any great famine or war should come, you displace silver, $1,000,000,000, and damage all the miners. There is no money to lend to the farmer and to trade, because the money is a debt and not a capital. You cannot make money out of a debt, but only out of capital (or savings).

It may be hard for some people to see through that reasoning, but it is as solidly true as the earth itself. Thus the Bank of France with its silver note lends to trade and to farmers through 258 branches; but with our credit paper we damn both silver and trade, and stand to be blown up financially in a war. So much for political banking; it is the curse of the 19th century. Sweep it away!

Restore silver! Destroy credit paper! You will have to tax yourselves of course, but you will have all the money in trade that you want. London money is now 1 per cent. per annum. In France about 3 per cent. Here it is 10 per cent., in the country.

Russia would make $300,000,000 profit by founding a silver note, because she would raise $960,000,000 paper from 60 per cent., present value, to 100 per cent. Yet the Czar has just ordered the issue of $100,000,000 more credit paper to be paid to the people for commodities. Such is the infatuation of European paternal politicians, that they cannot see they are only making matters worse; for, like our greenbacks, this paper will really be taking their goods on loan from them and giving them nothing but wind in return. Those who sow the wind shall reap the whirlwind.

Take Italy; if she would set all her soldiers to manual labor and employ the cash received in buying silver to back her credit paper, she would be able to redeem the hundreds of millions of silver that France holds against her. She would lift the value of her credit paper to par, and make hundreds of millions profit, besides blessing her people with lighter taxes, for the same tax, collected in paper which is at par, would produce a greater revenue and cure the dreadful deficits with which Italy is afflicted.

Austria too is full of forced credit paper, and all her business suffers in consequence; instead of handing over the monetary currency to a bank, she also follows paternalism and uses political banking.

All these credit paper nations have at present got a bad attack of the gold fever, and are proposing to sell their silver in order to put their paper upon a gold basis. But this will only make the matter worse, because the actual money needed to back these issues is something over $1,500,000,000, and that amount of gold cannot be found. It is true that Mr. Ottomar Haupt, the banker of Berlin, declares that there is no gold famine because all the gold that is wanted by Austria can be easily forced over from the United States. That is the effect of our credit paper; it flows out into the channels of commerce, growing every day in hundreds of thousands ($150,000 in new silver notes every twenty-four hours), and these being everywhere exchangeable for gold, it is only a question of time till the last gold dollar will be driven out. But even if all the gold in the United States of America should be taken away by Europe to back their credit paper, still that would not be half enough to supply them. What would be our condition with all our gold gone? To what premium would all the gold contracts arise? What would the

debtors do to liquidate their gold contracts? Would it not bring on a revolution? Is there not a fear that the people, seeing how the politicians had wrecked the country, will revolt as they did against the Continental notes, and abandon the whole business by repudiation?

Despair is a dreadful master. When the people abandoned the $200,000,000 of Continental notes, what ruin, suicide and desperation followed the loss. How much greater would be that ruin, loss and desperation when the sum was $1,160,000,000?

The statement of Mr. Ottomar Haupt shows you that Europe can just throw us into that position whenever it pleases to do so. So we must take up our credit paper. I have just shown the abandonment of silver by the politicians, let us sum it up and see what Europe has so far begun to abandon.

Germany has abandoned	$257,500,000
Germany wants to sell	100,000,000
Russia has abandoned all silver	900,000,000
Austria wants to abandon	80,000,000
Italy has driven out	72,000,000
Italy wants to sell	10,000,000
Belgium has driven out and wants to sell	65,000,000
Greece has nothing but paper	25,000,000
Roumania sold	5,000,000

France stands alone in the wild, stormy frenzy against silver, quietly increasing her gold reserves week by week.

Cause No. 4 is the utter absence of control by bankers. In all the nations the bankers seem stupidly helpless. Why do they allow this credit paper in their several lands? Why do they not form societies to protest against it? The public abuse them as if their profession was that of thieves, when they are or should be the safeguards of trade and the rock of the state. Bankers tamely submit to abuse, and seem by this silence under abuse as if they were content to be classed, by the public, as thieves. The time has come when bankers must join and teach the people how wicked the politicians are, and save the people from the follies of credit paper and from political banking.

The remedy, of course, is an International Treaty. That treaty must embrace:

(1) The foundation of banks to control the issues.

(2) The abolition of credit paper and of political banking.

(3) The use of a silver note like that of the Bank of France, kept in constant redemption by the Federated banks, who hold the last gold and silver reserves.

Who shall negotiate this treaty? Expert banking ambassadors appointed by the Chief Executive; these to confer with similar ambassadors appointed by the nations. The free coinage of silver need not be touched at all; it does and can only destroy the use of silver, nor need the question of ratio be brought into it.

The true place then of silver in the circulation of the whole world is to issue in each country a true silver bank note, like that of the Bank of France, through the federated banks of each country, and to sweep away forever all false credit paper, and all political banking; to pay these bank notes only in silver, as the Bank of France does, and so force silver into use all over the world. There is no need to wait for England, though India must follow suit.

Will the nations adopt that treaty? They *must*. If they do not, the financial dynamite bomb of Credit Paper (upon which we are all sitting, England included), will burst one day with frightful force and send down our boasted civilization in ruins.

Suppose the nations adopted free coinage of silver; then as fast as the silver coins went into circulation the credit paper would drive them out of the country, just as the fractional currency paper drove out our subsidiary silver in the United States of America into Canada and into Mexico, and robbed us of millions of dollars to redeem them again, so the credit paper will surely drive out free silver too. Thus the free coinage of silver would tax the people 50 per cent. to undertake it, because the 65-cent dollars would collect 100 cents worth of labor or goods from them in the exchange, and then would leave them worse off than before, with nothing but credit paper again.

The nations *must* adopt banking also, because of the great profit they will make by raising all the credit paper to par, and all the silver in the world to par. The profit will be, first on the sum of $3,600,000,000 credit paper placed upon a banking basis; and then on $3,700,000,000 silver restored to 129 cents an ounce, besides on the $3,000,000,000 of silver which will be mined in the next 20 years, and which will bring 129 cents per ounce instead of 85 cents per ounce.

How will the nations pay the taxes? Going back to old days of heathen Rome, we see today those old Roman roads which have stood the storms and changes of 2,000 years. Those roads were made by the Roman soldiers. It was the practice of Romans, in order to keep their soldiers strong in body, and in full discipline, to make the soldiers do work in building roads, aqueducts and canals. Suppose

the idle soldiers in the barracks of the Christian nations were put to work to make railroads and canals through all the countries of all the nations of the world, and the money earned by their labor being paid in silver to the several Christian Treasurers the bill would foot up in this way : 8,000,000 soldiers at $1.00 a day, taking 300 working days in the year, would give a yearly receipt of $2,400,000,000 of silver to be received every year, that would soon put the credit paper to rights and raise silver to par without even asking England's permission.

Then the canals and electric railroads, made by these strong men, would lift up the power and wealth of the countries many, many fold, increase the value of property, and lower taxation all over the world. While the soldiers (if you must have them) would be more healthy with 12 hours a day hardwork, more free from disease, more noble in soul and body, useful, instead of hurtful, ornamental to mankind instead of being a financial nuisance.

Where there's a will, there's a way. Now that (for the first time in the history of mankind) the mask has been torn from the face of the politicians, it remains for the people of the earth to carry out this plan and to redeem themselves from the curse of credit paper, from the heavy war taxes and to begin the reign of that promised peace for which we hope, when mankind, redeemed from war with its armies shall sing : " Glory to God in the highest, peace on earth, good will to man."

These are a few replies in answer to criticisms by bankers :

BANKER.—Tell me! How would you dispose of the greenbacks ?

ANSWER.—Call them in and replace them with a 2 per cent. bond, as was done by Hon. Charles Foster with the 4½'s in 1891. That would put an end to them without trouble, if you passed a law repealing their legal tender power, and forbidding all credit paper.

BANKER.—How would you extinguish the National Bank credit paper, which you condemn ?

ANSWER.—In the same way ; let the National banks redeem their notes and surrender the bonds as fast as the notes are redeemed.

BANKER.—How would you deal with the silver certificates ?

ANSWER.—Hand them over as deposit receipts to the federated clearing houses and let the Central Clearing House Bank call them in for a true silver bank note (like the Bank of France) ; that would enable the Central Clearing House to lend to the Nicaragua Canal $100,000,000, and to lend to farmers, and to trade (but only through

local clearing houses and banks, on three-fold security) $100,000,000 more in silver.

BANKER.—How would you found the Central Clearing House Bank?

ANSWER.—As already shown in the *California Bankers' Magazine.* That is, join all the local clearing houses into a federation, electing 12 directors to form the board of the Central Bank, which should be placed centrally. Let all the loans of coin be made by notes issued to the local clearing houses, and by them to the several banks. Each bank to have its notes stamped with its own name, and to be paid two thirds of the net profit on the amount kept in circulation for 12 months, the remaining third to be the profit of the people of the United States. The Treasurer and Comptroller of the Currency and Director of the Mint to be ex-officio members of the central board of directors. All government funds to be banked in the local clearing houses.

REGULAR MEETING, MAY 6th, 1892.

PROCEEDINGS.

MINUTES.

Meeting held in the main hall of the Academy of Sciences; called to order by the President, John Richards.

The reading of the minutes of the last regular meeting was dispensed with.

The following new members, having been balloted for, were declared elected:

William H. Davenport, Irrigation Engineer.....Visalia, Cal.
Robert Hall, Mechanical Engineer.....San Francisco, Cal.
W. O. Secor, City Engineer .....Albuquerque, N. M.
M. M. O'Shaughnessy, Civil Engineer.....San Francisco, Cal.
Alexander Watson, Mechanical Engineer.....San Francisco, Cal.

The following names were proposed for membership and referred to the Board of Directors:

John W. Gray, Hydraulic Engineer, Oakland, Cal.; proposed by Hubert Vischer, C. E. Grunsky, Luther Wagoner and James D. Schuyler.

John H. Wallace, Ass't Engineer, Maintenance of Way, S. P. Co., San Francisco, Cal.; proposed by C. E. Grunsky, Marsden Manson and Otto von Geldern.

Willard D. Johnson, Topographer U. S. Geological Survey, Berkeley, Cal.; proposed by Hubert Vischer, John Richards and C. E. Grunsky.

Mark B. Kerr, Civil Engineer, San Francisco, Cal.; proposed by Hubert Vischer, Luther Wagoner and Otto von Geldern.

The President announced the death of Mr. L. L. Robinson, member of the Technical Society, and appointed the following committee to draft suitable resolutions: Aug. J. Bowie, Jr., Hubert Vischer, and C. E. Grunsky,

Mr. J. W. Treadwell, Editor of the *California Bankers' Magazine*, delivered a lecture before the Society entitled "Silver, its true place in the currency," which was discussed.

Adjourned. OTTO VON GELDERN, *Secretary.*

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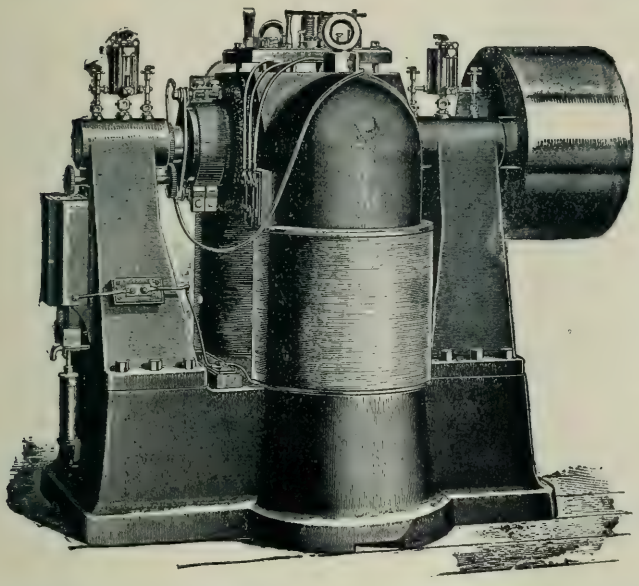

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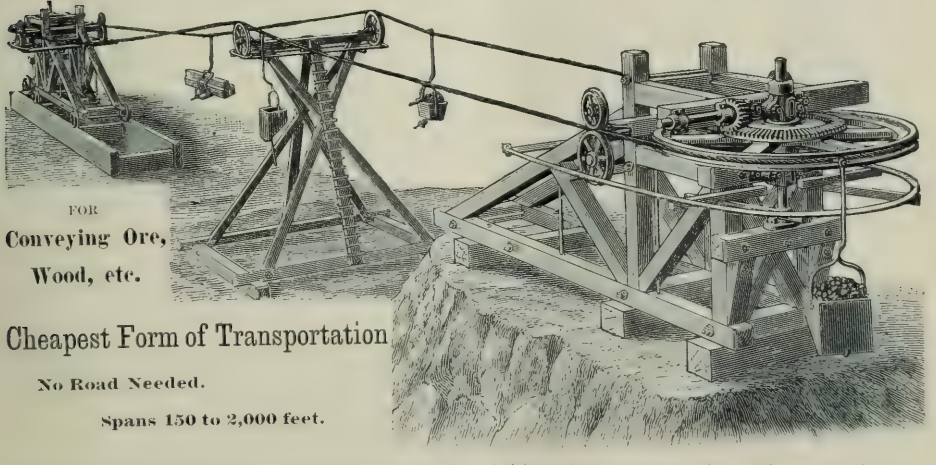

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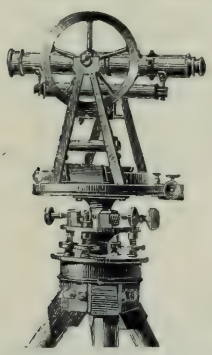

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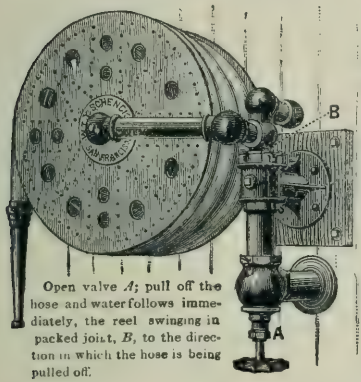

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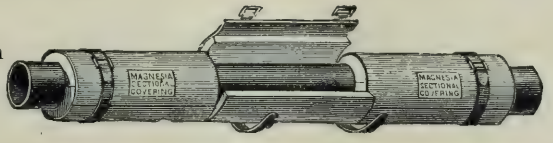

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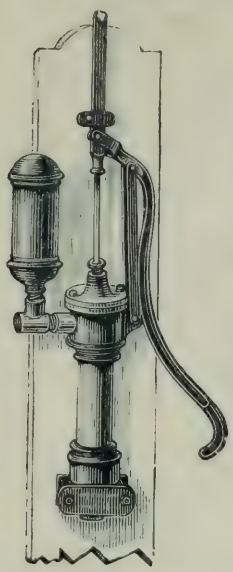

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TRANSACTIONS.

(VOLUME IX. No. 4.) 5

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

THE CIRCULATION OF THE ATMOSPHERE OF PLANETS.*

BY MARSDEN MANSON, C. E., Mem. Tech. Soc.

[Read June 3d, 1892.]

The movement of the atmosphere about the globe is a problem of great interest and importance. The apparently complicated character of this movement, the transparency of the atmosphere itself and the difficulty of conducting observations, except near the surface of the earth, present conditions which render the study of the problem difficult.

The conclusions reached after careful investigations should, if correct, be applicable to the corresponding phenomena upon any other member of the solar system, and under the conditions known to exist should explain these phenomena. The explanations, which the author has been able to find in the various treatises and articles

* The Author was prompted to entitle this paper as above, from the fact that it thoroughly explained the movements of cloud spots in the atmosphere of Jupiter. The original title was therefore changed by substituting the word planets for the earth.

on the subject, when applied to the known movements of spots in the atmosphere of Jupiter, instead of explaining the grand phenomena there presented, involve them in obscurity and doubt as to the actuating cause, and require the student to resort to assumptions and hypotheses which cannot be verified.

It is proposed in this paper to develop the prime mode of action of solar energy in producing atmospheric circulation upon the globe, and to apply the same reasoning and methods to elucidate the apparently confusing movements in the Jovian cloud system.

It is a known fact, established by many extended series of observations, that the barometer has, at all latitudes, a daily variation caused by the action of solar energy. This rise and fall is greatest in the torrid zone, gradually dying away to an almost imperceptible phase in the polar regions.*

This phenomenon assumes the form of a diurnal pulsation, with a maximum about 9 A. M. and a minimum about 3 P. M., with a tendency to a corresponding maximum and minimum at 9 P. M. and 3 A. M. These latter pulsations are much less pronounced, and in the higher latitudes are scarcely appreciable. The diagram, Fig. 1, illustrates this very marked feature.

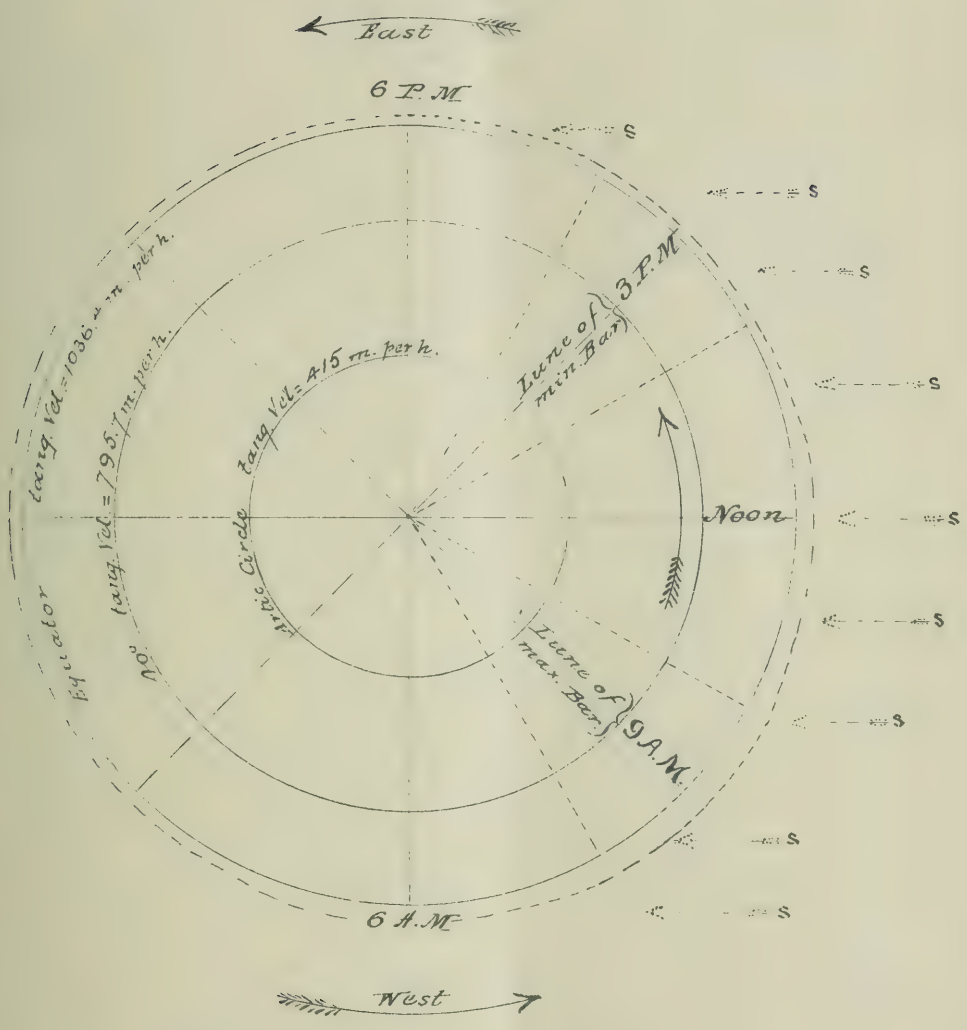
It will be observed: (1) That under these conditions the lune of daily minimum barometer is always in the easterly quadrant of the illuminated hemisphere, that the lunes farther east have just been exhausted, and that those to the west are at their maximum. (2) That this action takes place continuously at each revolution of the earth. (3) That cloudiness accelerates and intensifies the action by appropriating all of the solar energy reaching the clouded areas. (4) That it is not counteracted in any way whatever.

Therefore there results a constant lune of lowest barometer always in the easterly quadrant of the illuminated hemisphere, which, by reason of the axial revolution of the earth, moves around the earth from west to east about 90° (or 6 hours) east of the lune of maximum barometer; this condition can only be satisfied by a constant flow of air in the direction of this barometric gradient, or from west to east.

As solar energy has its greatest effect in the torrid zone and gradually decreases toward the poles, westerly winds and vertical currents reach their maximum in that zone, and the lower strata of air in each hemisphere have a slight trend toward the equator, and

* See Physical Geography of the Sea, Maury, page 210 (8th edition). Elementary Meteorology, page 88-91; R. H. Scott, F. R. S., London, 1890. Deschanel's Natural Philosophy, 6th edition, page 165.

Fig. 1



Scale $\frac{1}{125\,000\,000}$

the upper strata a necessary counter current toward polar regions, as shown in Fig. 2.

It becomes necessary here to explain the apparent stoppage of the winds in the calms of Cancer and Capricorn ; the apparent reversal of the west winds into the easterly trades of the torrid zone ; and the existence of a calm belt between these two belts of easterly trades.

Let us assume a sphere in space, without axial rotation, and surrounded by an atmosphere similar in composition to that of the earth. Around this sphere let us further assume a beam of heat and light to revolve from east to west, successively heating the air. Barometric phenomena, similar to those now known to take place and illustrated in Fig. 1, will be inaugurated ; and if the revolutions of the beam of heat could be accomplished in 24 hours, and the heat received by each hemisphere be in whole or in part lost during the following period of non-exposure, the atmosphere surrounding our illustrative sphere would flow around it from west to east ; and as the zone of nearly normal rays would be most acted upon the west winds of that zone would be the strongest and the vertical circulation greatest. There would also be established a series of counter currents in the upper atmosphere trending toward the poles, the resulting circulation would be as represented in Fig. 2.

It will be observed : (1) that the strongest westerly winds and vertical currents will obtain in the torrid zone of our non-rotating sphere, and that these winds will gradually decrease in force toward the poles, to die away in the polar regions. (2) That surface currents will trend toward the equatorial regions by reason of the greater vertical circulation there established, and an upper system of counter currents will trend toward the polar regions.* These two wind systems will therefore be as represented by the full and dotted arrows in Fig. 2 ; the varying lengths being intended to indicate the proportionate strength of the currents.

Now, instead of the assumed and impossible stationary sphere and revolving beam of heat, let us substitute the simple and actual stationary beam of heat and the rotation from west to east of the sphere. There will be no change in the forces tending to cause the

*It is immaterial whether the atmosphere be entirely diathermous or not. In the cases of the Earth, Mars, Venus and Mercury, heat rays pass quite freely through the atmosphere, and reach the surface. In the case of Jupiter, and probably Saturn, Uranus and Neptune, all, or by far the greater portion, of solar heat rays is absorbed by the atmosphere of those planets. The only modifications of the resulting circulation are a modification of the height of maximum activity above the surface, and a comparative increase of velocity in all latitudes. These two classes therefore cover the conditions existant upon all the planets. (See also the Cause of the Glacial Period, etc., Transactions Technical Society, Pacific Coast, Vol. 8, No. 2, Sept. 1891.)

atmosphere to circulate about the sphere, nor will conditions be introduced which would in any way tend to counteract such circulation, but remarkable relations between the atmospheric circulation and the moving surface will be introduced. All latitudes of the surface will travel with the atmosphere, but with varying relative velocities in each latitude.

The question of whether the atmosphere would revolve with the planet, irrespective of the effect of solar energy, is not considered. The principal subject under discussion is the accelerating effect of solar energy. In temperate latitudes this accelerating effect is so great as to cause the atmosphere to revolve faster than the earth.

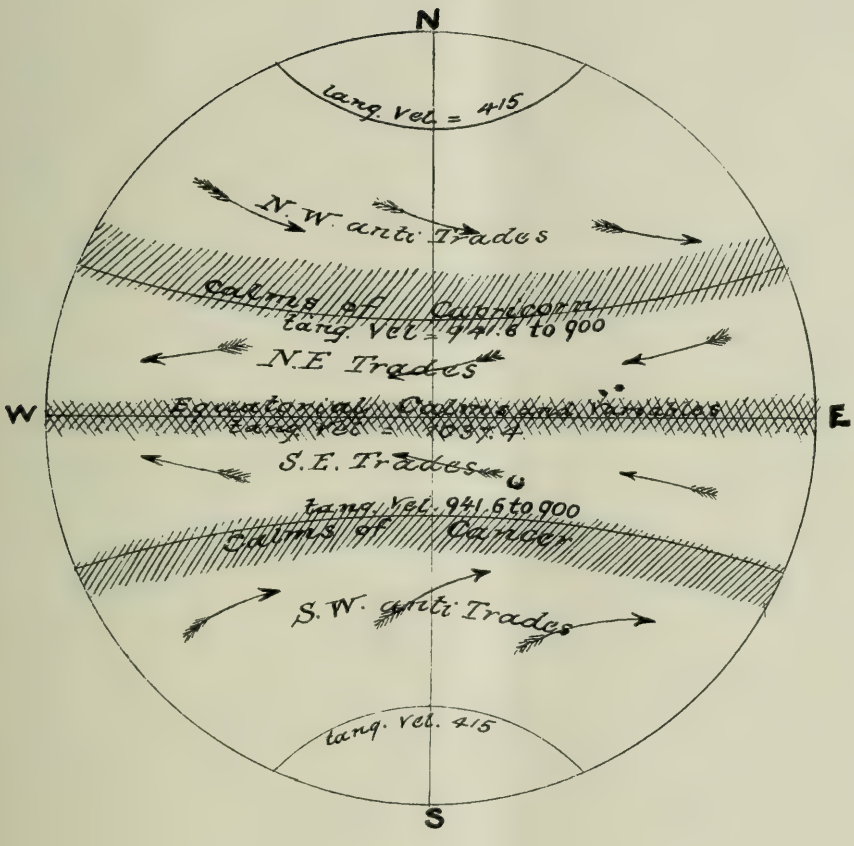
On Jupiter the equatorial belts of spots revolve faster than the surface of the planet beneath, as will be explained later.

These variations in tangential velocity are expressed in the table appended, giving the velocity of the surface at sea level for each 10° of latitude. It is practically correct, but subject to very slight corrections, as the exact form and dimensions of the earth shall be more minutely ascertained.

TANGENTIAL VELOCITY OF EACH TEN DEGREES OF LATITUDE FROM THE EQUATOR TO THE POLES.

Latitude.	Tangential Velocity in Miles per Hour.	
0°	1037.4	
10°	1021.8	
20°	975.3	
23½°	941.6	Tropics.
30°	899.1	
40°	795.7	
50°	668.1	
60°	520.0	
66½°	415.0	Polar Circles.
70°	355.8	
80°	180.7	
90°	00.0	

Fig. 3



Scale $\frac{1}{125000000}$

VELOCITIES EXPRESSED IN MILES PER HOUR

The appended diagram of the wind systems of the globe, Fig. 3, is familiar and generally accepted. The variations are many, and produced by various causes, the principal of which are the different proportions of solar energy taken up by ocean and continental areas; the varying exposure of winter and summer, and the transfer of heat by ocean currents, each of which locally complicates the actual phenomena, but all are foreign to a discussion of the prime problem and will not now be considered.

It will at once be admitted that in the region of the anti-trades, or north and south of the calms of Cancer and Capricorn, the circulation agrees with that established and explained in Fig. 2. In other words, between 35° and 60° in both hemispheres, the air circulates about the globe from west to east a few miles faster per hour than the tangential velocity in those latitudes. But about latitude 30° the acceleration in tangential velocity brings it up to the westerly circulation of the atmosphere, and both reach a velocity of about 900 miles per hour, and hence a region of calms. Between these two calm belts there is a zone in which the motion from west to east is actually greater than in the calm zones on each side, but owing to the proportionately greater increase in tangential velocity these stronger west winds appear to be east winds — the earth slipping under the air faster than the air circulates.

In the center of this great belt of easterly trades is a narrow belt of calms and variables — in which the velocity of the atmosphere and the tangential velocity are equal.

This narrow belt of calms is under the equatorial cloud ring* which intercepts, in the atmosphere, a larger proportion of solar energy than the less clouded areas to the north and south of this ring. The effect of this intercepted heat is to accelerate the west winds of that region, thus equalizing the two velocities and resulting in the equatorial calms. Again the rains of that belt are, as elsewhere, accompanied by cyclonic motion, in two quadrants of each cyclonic area the wind motions are either from the west or from the east; in the former, the acceleration aids in bringing atmospheric motion up to an equality with the tangential velocity, hence the apparent calm on one side of an equatorial storm center, and the terrific force of the wind on the other.

The relations between the tangential velocities at various latitudes, and the corresponding actual and apparent surface wind velocities, are outlined in their general features in Fig. 4.

* See Physical Geography of the Sea, Maury, 8th edition, page 209.

It would be difficult to verify these views from ordinary meteorological observations, particularly in the torrid zone; but an opportunity to observe the movements of the atmosphere on a grand scale was inaugurated on August 27th, 1883, when in latitude 6° 9′ S., the volcanic island of Krakatoa, in the Straits of Sunda, exploded with a degree of violence unknown in historic times.*

The Royal Society of London appointed a Committee in December 1883, to collect and put on record the observations made throughout the world upon the consequent phenomena. The results of the labors of this able Committee were published in December 1888, by J. G. Symonds, F. R. S., Chairman of the Committee. From this valuable work the following outline is condensed:

The most violent explosions were heard at a distance of 2,500 miles, and over $\frac{1}{13}$ of the area of the globe, and threw a column of volcanic dust and vapor to a vertical height of from 17 to 31 miles. The wave of pressure traversed the globe to the antipodes of Krakatoa in 16 hours, and successively rebounding back and forth compassed the globe seven times before subsiding. Every barometer marked seven successive passages of this rebounding wave, but its passage was rarely recorded except upon the barographs of the observatories. Masses of lava were thrown to a distance of 50 miles, with an initial velocity twice as great as a shot from the modern breech-loading rifle. The total volume displaced was about 1⅛ cubic miles.

This vast dust column was borne by the winds twice and a half times around the earth before being dissipated, making each circuit in about 12½ days in a westerly direction, and at an average rate of 70 to 77.2 miles per hour. The probable maximum speed being estimated at 80.3 miles per hour, and by the celebrated Dutch engineer Verbeek at 82.9 miles per hour.

In the first circuit the diffusion was over a zone of about 31° in width, in the second about 60° in width, the center of each zone being practically the latitude of the explosion.

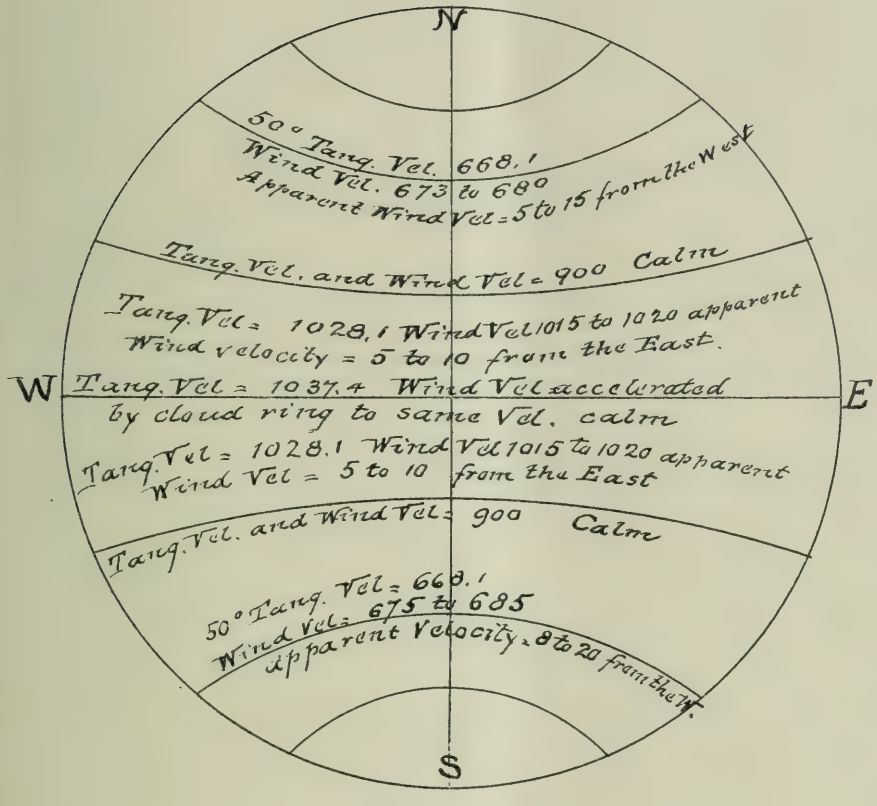
After passing latitude 35° N. the further extension up to 60 N. was from the S. W.

From page 431 of the Report cited, the following quotation is introduced:

"If we analyze these, we shall find that on their first circuit, the mean latitude of the center of the band of the twilight glows, was

*At that date the sun was vertical over Latitude 13° 55′ N.

Fig: 4


N
50° Tang. Vel. 668.1
Wind Vel. 673 to 680
Apparent Wind Vel = 5 to 15 from the West
Tang. Vel. and Wind Vel = 900 Calm
Tang. Vel = 1028.1 Wind Vel 1015 to 1020 apparent
Wind velocity = 5 to 10 from the East.
W
Tang. Vel = 1037.4 Wind Vel accelerated
by cloud ring to same Vel. calm
E
Tang. Vel = 1028.1 Wind Vel 1015 to 1020 apparent
Wind Vel = 5 to 10 from the East
Tang. Vel. and Wind Vel = 900 Calm
50° Tang. Vel = 668.1
Wind Vel = 675 to 685
Apparent Velocity, 8 to 20 from the N.
S

Scale $\frac{1}{125,000,000}$.

Velocities expressed in miles per hour

6° 10′ S. (the latitude of Krakatoa being 6° 9′ S.) and their mean extension north and south of this position was ±15½°.

For the colored suns, the mean latitude of the center of the band was 5° 26′ S., and the mean extension of the phenomenon north and south of this, was ±10° 49′. The latter, therefore, was more restricted than, but very similar in position and extension, to the former.

During the second circuit the limits are not so determinate; but omitting extremes, we may take the twilight glow band to have had its central line about 6° S., and to have extended north and south of this for about ±30°.

Up to October 5th, this rate of expansion for the stream seems to have been fairly maintained, but after this epoch we find a distinct retardation in the latitudinal spread of the main body of the haze, and thenceforward its course is doubtful. Apparently, it reached latitude 35° by the end of October; then, in November, a sudden rush took place, which by the end of the same month, caused the phenomenon to be seen over the major part of North America and Europe, up to latitude 60°. A change in the direction of motion appears to have taken place in October, after which the material seems to have been wafted along by a different set of currents.

Whether the material spread by the action of any other laws than those which usually regulate the motion of the air in which it floated, and at what time it ceased to move from east to west, it is difficult to say,*†‡ but the facts negatively favor the view that by the time it reached latitude 30° it no longer possessed that due east to west direction, by which, at first, its general motion within the tropics was so markedly characterized. Beyond this limit, the facts relating to the march of the glows over North America, Europe, and Northern Asia, show that the current which brought the glow-causing material, whether simply the south-west anti-trade or a current analogous to it at a higher level, carried it more from west to east than from east to west. There is, indeed, a remarkable absence of any succession of appearances from east to west, beyond latitude 30° N., *and a general impression conveyed by the facts that while the material was crossing this limit, it was simply spreading north and south, and afterwards turned around so as to move, if anything, from south-west to north-east.*† If this was the case, its general motion beyond the tropics was similar to what that of the usually so-called higher parts of the atmosphere should be, according to the modern theory of atmospheric circulation."

It will be observed that in this quotation, very important facts are recorded, but that a remarkable interpretation of them is rendered in referring to the apparent motion of the dust cloud, at from 70 to 83 miles per hour, from east to west, as an actual velocity in

*Such as electrical repulsion. †Italicized by the Author.
‡"The apparent motion of the wisps of cloud haze observed by Prof. Ricco and Mr. Russell."

that direction—when in reality, at no other latitude could this dust cloud have been borne in the opposite direction at the high rate of speed noted below.

The fact that this dust cloud traversed the earth twice between latitude $\pm 30°$, is beyond dispute. The observed time of passage was 12½ days, or 300 hours. The distance accomplished in each circuit was the equatorial circumference of the globe at an altitude of 20 or 30 miles, or practically 25,000 miles. The tangential velocity of the equator is 1037.4 miles per hour from west to east.

By that well-known and useful principle established in the "Problem of the Couriers," we have the time necessary for one body to overtake another moving at a different rate, is found by dividing the distance between them by the difference of their rates of speed, or $T = \frac{D}{r - r_1}$. In which T = 300 hours; D = 25,000 miles; r = 1,037.4 miles per hour, to find r_1.

Substituting these values, we find $r_1 = 954.$ miles per hour. The sign being positive, the direction of motion is the same as the tangential velocity, *and the difference between the two velocities is 83.4 miles per hour.* In other words, the dust cloud, instead of being borne around the globe from east to west at an average speed of 83.4 miles per hour, was actually travelling in the opposite direction at a speed nearly eleven and one half times greater, but the lost motion, or lagging behind the tangential velocity, was 83.4 miles per hour, giving an *apparent motion* from east to west. When the dust cloud reached the latitude of the tropics, or the calm belts, it traveled at the same velocity as the surface beneath, hence the "retardation" in October, 1883.

Upon passing north of the calms of Cancer, the haze reached the south-west upper currents, overspreading the north-west anti-trades, and moving faster than the surface beneath, and hence the apparent change in the direction of motion, and its spread over Northern Asia, Europe and North America from the south-west. The change in direction spoken of in the quotation given, was only an apparent change, and the distinguished Committee, in failing to correctly interpret the facts, found it necessary to partly attribute the motion of the dust cloud to "other laws than those which usually regulate the motion of the air in which it floated."

But when the principles herein developed are applied to the phenomena attending the movement and spreading of this volcanic

dust cloud, these movements become grandly simple, and part of one harmonious whole.

We can also more readily interpret the two calm belts about the tropics; starting in the torrid zone or region of apparent east winds, where the tangential velocity is greater than the atmospheric circulation, and passing to the temperate zones, where the atmospheric circulation is the greater, we must pass through regions where the two motions become equal, or the calm belts. Beyond these are the anti-trades, or the region of actual westerly winds, in which the motion of the atmosphere is the greater.

In the regions of north-west and south-west trades, there is a proportionately greater acceleration, due to the greater appropriation by the atmosphere of the heat rays reaching those latitudes. By reason of the obliquity of solar rays, in latitude $\pm 50°$, nearly twice as thick a stratum of air must be passed through as at the equator; hence a larger proportionate amount of heat is taken up, and proportionately a greater acceleration is acquired by the atmosphere of those latitudes.

Thus the apparently confusing motions of the dust cloud in latitude 35° N., and its apparent reversal of motion in approaching Europe and North America from the south-west, become part of a general circulation, always in the same direction, and in accordance with the same fundamental laws, acting in the same manner and in the same direction in all latitudes.

This velocity of 954 miles per hour, is that obtaining in the higher regions of the atmosphere about the torrid zone. The relative surface velocities are more nearly as represented in Fig. 4. If the actual velocities of the atmosphere at various latitudes be compared with the scheme deduced from Fig. 2, the correctness of this latter is at once established.

In the temperate zones the actual surface velocities are about 675 to 680 miles per hour, gradually increasing to $\pm 30°$ where velocities of about 900 miles per hour exist. In the tropical trade-wind belts the actual velocities are from 1,010 to 1,015 miles per hour; and under the equatorial cloud ring the actual velocity is about 1,037 miles per hour. The differences between these velocities, and the tangential velocities of the corresponding latitudes, give the apparent directions and forces of the winds.

The northerly and southerly components are omitted in this discussion, which is limited to the fundamental principles. The Krakatoa dust cloud traversed the globe twice before passing north of the tropical calm belt, or, in going through 720 degrees of longitude, it went from 6° south to 30° north latitude, or in the ratio of 20 to 1. At the surface these components are relatively more nearly equal in value, and hence the directions of surface winds are more oblique to the meridians than the ratio above given would indicate.

Application of the Foregoing Principles to the Atmospheric Circulation of Jupiter.

PHENOMENA PRESENTED UPON JUPITER.

When the physical conditions and phenomena existent upon Jupiter are fully grasped, they present a remarkable confirmation of the principles just developed for the earth.

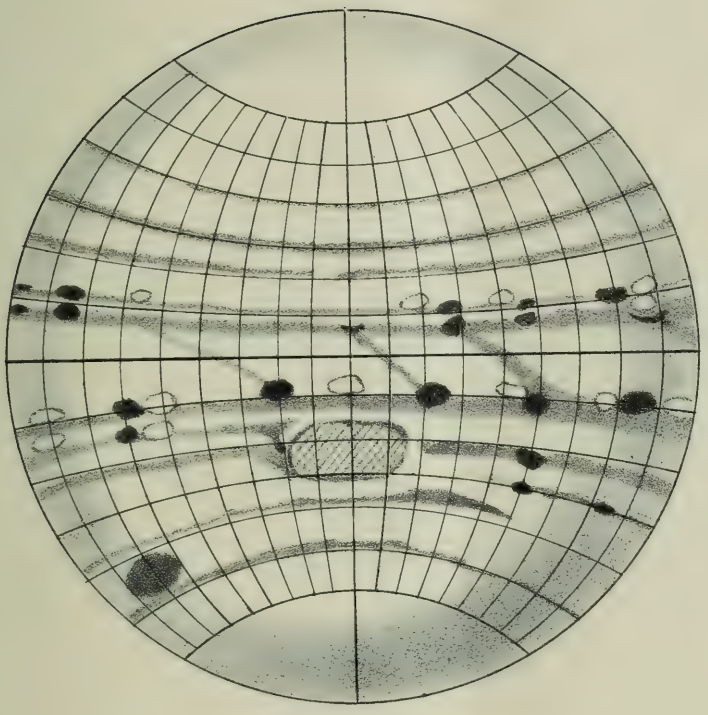
So far as our knowledge of Jupiter now extends, that planet is a mass of unknown size, shrouded in a densely clouded atmosphere. Not knowing the surface temperature of the inner planetary mass, nor the composition of the atmosphere, it is impossible to approximate the limit to which the gaseous envelope has been expanded.* The cloud sphere evidently encloses a planetary mass, in which is still resident sufficient heat to control surface temperatures and to cause evaporation, thus maintaining the cloud sphere, and preventing the loss or receipt of heat by radiation.†

That evaporation is kept up on Jupiter by internal heat, is demonstrated by the following facts; (1) being 5.2 times more distant from the sun than the earth, he receives $\frac{1}{(5.2)^2} = .037$ of the heat per unit of area which the earth receives; (2) as will be shown later, this feeble amount of heat is entirely taken up in the atmosphere in producing an atmospheric acceleration about the equatorial regions, greater than the corresponding acceleration on the earth. This decreased solar energy by reason of producing a greater comparative acceleration, must therefore, be taken up in the atmosphere to a greater extent than in the case of the earth. The

*The density of this planet is calculated from its weight and the observed diameter of the enveloping cloud sphere. This result is low in proportion to the height to which the cloud sphere is expanded by internal heat.

†See also, Transactions of the Technical Society, Vol. 8, No. 2, Sept. 1891.

Fig: 5.



THE PLANET JUPITER, 1887.

MODIFIED FROM THE MERCATOR'S PROJECTION

IN

ZENOGRAPHICAL FRAGMENTS

very existence ,therefore, of the cloud shield is evidence of a surface temperature maintained by internal heat. It is also evident that as radiated solar energy does not penetrate the cloud shield to the surface, internal heat is not lost by radiation, and that the function of the mild solar energy reaching that remote planet is simply to conserve the internal heat. Jupiter having a diameter 11.2 times larger than that of the earth, and being 5.2 times more distant, intercepts 4.64 times more heat ; every thermal unit of which, has only this conservative function to perform.

The surface of this cloud sphere is marked by a series of bands and spots ranged in zones parallel with the equator. These spots are either dark or light and exist for many months. Their periods of revolution are observed with great accuracy. After these bands and spots, the most notable feature is the Red Spot, situated in the southern hemisphere, and extending from about 15° S. to 32° S. and over 35° of longitude, or one-eleventh of the circumference of the planet. (See Fig. 5.)

The Red Spot has a mean period of revolution of 9 h. 55 m. 38.4 s., with a retardation of a few seconds per year for about six years, and then a similar acceleration. The most rapid revolution is 9 h. 55 m. 24.2 s., and the slowest 9 h. 55 m. 41.1 s.* The spots in the bands have periods of revolution of from 9 h. 55 m. 46 s. to 9 h. 50 m. 9.5 s.

Those immediately adjacent to and north of the Red Spot have periods of revolution some five minutes less than that of the Red Spot, so that in about forty-five days, they make one more revolution than it does, or they make 110 revolutions whilst the Red Spot makes 109. This swifter motion causes them to pass by the Red Spot, when it exercises a "repellant influence" upon them. Mr. Williams refers to the results of his observations as "demonstrating the great probability of the existence of a real repulsive influence exercised upon neighboring objects by this remarkable formation.†" But he offers no explanation of this phenomenon. The spots more remote from the Red Spot have nearly the same period of revolution. All of these periods of revolution are therefore variable, these variations are set forth in the accompanying table from a recent and very able work, *Zenographical Fragments*, by A. Stanley Williams, F. R. A. S.

The column of latitudes has been added by the writer from other parts of the same work. These latitudes mark approximately the

*Zenographical Fragments, page 97. †Zenographical Fragments, page 117.

center of each spot. There has also been added the column marked "Size," in which the letters *L* and *S* mark the large and small spots, the others being medium in size.

SUMMARY OF ROTATION PERIODS.

MEAN MOTION OF MATTER IN DIFFERENT ZENOGRAPHICAL LATITUDES IN 1887.

North Temperate Spots.	H	M	S	Latitude	Size
White Spot A	9	55	34.7	$12\frac{1}{2}^\circ$ N.	
Dark Spot B	9	55	40.4	10°	L
White Spot C	9	55	32.6	$12\frac{1}{2}^\circ$	L
Dark Spot D	9	55	37.7	10°	L
White Spot D^2	9	55	34.1	$12\frac{1}{2}^\circ$	L
Dark Spot E	9	55	27.3	10°	S
White Spot F	9	55	30.0	$12\frac{1}{2}^\circ$	L
Dark Spot G	9	55	26.0	10°	L
White Spot H	9	55	26.8	$12\frac{1}{2}^\circ$	.
Dark Spot H^2	9	55	40.7	10°	S
White Spot K	9	55	38.6	11°	L
Dark Spot K^2	9	55	39.4	10°	S
White Spot L	9	55	38.5	13°	.
Dark Spot M	9	55	43.1	11°	L
White Spot N	9	55	46.0	12°	S
Dark Spot O	9	55	44.0	10°	
White Spot P	9	55	40.4	$12\frac{1}{2}^\circ$	

North Equatorial Spots.	H	M	S	Latitude	Size
Dark Spot 1	9	50	16.6	8° N.	
Dark Spot 2	9	50	33.3	8°	
Dark Spot 3	9	51	18.7	5°	L
Dark Spot 4	9	50	44.9	4°	
Dark Spot 5	9	50	26.8	8°	L

South Equatorial Spots.	H	M	S	Latitude	Size
Dark Spot I	9	50	22.3	10° S.	
White Spot II	9	50	20.4	7½°	
Dark Spot III	9	50	21.7	10°	L
White Spot IV	9	50	17.4	7½°	
Dark Spot V	9	50	9.5	8°	L
White Spot VI	9	50	12.0	5°	
Dark Spot VII	9	50	19.7	8°	L
Dark Spot VIII		?		8°	
White Spot IX	9	50	24.9	6°	
Dark Spot X	9	50	19.2	6°	
White Spot XI	9	50	15.5*	6°	L
Dark Spot XII	9	50	19.0*	10°	L
White Spot XV	9	50	21.9	7½°	
Dark Spot XVI	9	50	24.0	10°	
White Spot XVII	9	50	25.4	7½°	L
Dark Spot XVIII	9	50	19.7	7½°	L
White Spot XIX	9	50	18.0*	7½°	L
Dark Spot XX	9	50	24.3	11°	S
White Spot XXI	9	50	25.2	7½°	
Dark Spot XXII	9	50	27.2	8°	
White Spot XXIII	9	50	26.6	7½°	S
Dark Spot XXIV	9	50	18.7	10°	
White Spot XXV	9	50	29.7	7½°	
Dark Spot XXVI	9	50	36.5	10°	
White Spot XXVII	9	50	24.1	7½°	S

*Spots marked thus have been rejected in ascertaining the mean motion of matter in about latitude 8° S. Their periods of rotation not being known with sufficient accuracy.

Southern Spots.	H	M	S	Latitude	Size.
Red Spot	9	55	40.5	24° S.	L
White Spot α	9	55	21.6	30°	
Dark Spot β	9	55	11.8	30°	
Dark Spot γ	9	55	17.8	30°	

	H	M	S
Mean period of rotation of matter (from 17 north temperate spots) in Lat. 12° N	9	55	36.49
Mean period of rotation of matter (from 5 north equatorial spots) in Lat. 4° N	9	50	40.06
Mean period of rotation of matter (from 21 south equatorial spots) in Lat. 8° S	9	50	22.4
Mean period of rotation of matter (from 3 southern spots) in Lat. 30° S	9	55	17.1

(See page 111 of the work cited.)

It is worthy of note, that the dark spots, by reason of their greater power of taking up solar rays, have, under direct solar energy, slightly shorter periods than white spots under the same exposure.

The only apparent deviation from this is in the spots in the north temperate regions. The mean period of all white spots being 9 h. 55 m. 35.74 s., and of dark spots, 9 h. 55 m. 37.32 s., or 1.58 seconds longer. But when the doubtful and complicated determinations of the periods of each class of these spots be eliminated, as is warranted in the very detailed notes given in the text quoted, the remaining dark spots revolve 2.1 seconds faster than the remaining white ones. The convex or concave form of the spots may also have affected the results, particularly under oblique rays.

A large dark spot has a slightly increased rate of motion over a small one, and a large white spot a slower rate than a small one.

The delicate character of the balance between the amounts of solar energy appropriated by white and dark surfaces is thus beautifully shown. It is probable that the white spots are gyratory columns of warm air rising from the surface, and the dark ones,

similar gyratory columns of cold air descending; the two forming parts of the system of vertical circulation.

It has been observed that, during periods of great brilliancy and distinctness, the spots of the equatorial regions are subjected to a wave of acceleration passing westwardly in its action. The interpretation of this is, that in the upper strata of the Jovian atmosphere, heat and light rays are at times partially arrested by cirrus clouds; during such partial interruption retardation takes place, and during non-interruption increased brilliancy and acceleration occur. The westward motion of the wave is due to the retardation in the cirrus cloud strata.*

From the table just given it will be noted:

(1). That cloud spots in the south equatorial regions had, in 1887–8, a period of revolution faster than in any other portion of the visible surface.

(2). That in the north equatorial regions nearly equal periods of revolution were maintained.

(3). That in the temperate latitudes longer periods of revolution prevailed than in equatorial latitudes.

(4). That the Red Spot had a period of revolution distinctly slower than the adjacent cloud spots.

AN EXPLANATION OF THESE MOTIONS.

The Red Spot being the most permanent feature, an explanation of its oscillations and influence will first be offered.

It is evidently caused by the local escape of internal heat from the mass beneath, the repellant influence being due to the spreading of the heated currents as they rise, and to the consequent greater altitude and overshadowing effect of this remarkable feature.

The retardation and acceleration in its rate of revolution are due to the veering of the spot by the increasing force of west winds consequent upon the exposure of the southern hemisphere during one-half of the Jovian year, or 5.93 of our years. During the other half of the Jovian year these winds retreat northerly, permitting the Red Spot to assume a position in the atmosphere more nearly vertical over the source of heat beneath, thus apparently retarding its motion to the east.

This acceleration and retardation of west winds, and the annual shifting of the belt of their maximum activity are notably

*Just as in the case of the earth. The equatorial retardation in the upper regions having been shown to be 83.4 miles per hour. At the surface the retardation is practically zero under the cloud ring.

marked on the earth. It is very perceptible in its March and April passage over the central part of the continent of North America.* It is also well known in the correlated shifting of the belts of trades and calms in the tropical latitudes of each hemisphere.

Disregarding the accelerating effect of the summer west winds, and noting the mean period of rotation as fixed by 4,917 revolutions from July 10th, 1879, to Aug. 2nd, 1887, we have 9 h. 55 m. 38.4 s. as the length of the Jovian day. This is 4.2 s. longer than the shortest period observed in 1879–80, and 2.7 s. shorter than the longest period of revolution in 1885–6, about six years later.†

There also occurs in latitude 40° to 50° S., longitude 55° to 80° W., an indistinct spot of great size. So far as the author is aware, the exact time of revolution of this spot has not been observed. The opinion is ventured that it is caused by conditions similar to those producing the Red Spot, and that their periods are identical.

We have only to apply these principles to the varying periods of revolution of the belts of white and dark cloud spots in the atmosphere of Jupiter — and to bear in mind the non-diathermic character of his atmosphere — and these varying periods of revolution become simple, and in perfect accord with the explanations herein given for the wind systems of the globe. Indeed, the wind system of Jupiter is more simple than ours, the acceleration in velocity being directly proportioned to solar exposure, and no heat is lost by passing through to a planetary surface having variable heat appropriating powers.

In the equatorial regions of Jupiter, direct solar energy causes the atmosphere to revolve faster than the planet itself, and hence the spots of this belt pass the comparatively fixed yet floating Red Spot. This spot, however, obeys the accelerated force of the summer winds of the southern hemisphere, which increase in force for one-half of the Jovian year, or 5.93 years; during the other half these winds decrease in force, and the acceleration is in part lost. The center of this belt of strongest winds shifts over a zone 7° 11′ wide, the inclination of the plane of the equator to the plane of the ecliptic being one half of this arc.

In temperate latitudes the oblique rays are not capable of producing so great an acceleration, and hence the spots of these latitudes have longer periods of revolution. The northerly and southerly components of the earth's wind systems are also greater than on

* See pages 578 to 663 of the Report of the Chief Signal Officer, 1890.
† See page 97, Zenographical Fragments.

Jupiter. This condition is brought about by the decreased heat received by the latter planet, and his shorter period of axial revolution.

There are, therefore, presented on Jupiter the simplest and grandest phenomena of atmospheric circulation.

Over the whole of the surtace of Jupiter, a nearly uniform temperature must prevail, variations being caused only by elevation and proximity to areas from which internal heat escapes.* In the zone between $\pm 40°$, the winds bear the heated atmosphere to the east of the heated surface areas. North and south of these limits the diffusion is more general, and may, in polar latitudes, be reversed by a retardation of atmospheric circulation.

It is impossible to determine the geological age now prevalent upon this great planet. His vast mass has retained sufficient heat to assure us that geologically he is younger than the earth. But of this we may be certain, the age corresponding to our great Ice Age has not yet passed, and the dominion of solar heat over the surface climates of Jupiter has not yet been established.

DISCUSSION.

Lieutenant J. P. Finley read the following paper in criticism, remarking before reading the criticism, that in subjects of this kind, the work must be based very largely on careful observation. The tendency in meteorology is to give one's attention too much to theoretical discussion. It is a very fascinating subject in certain directions, and one is tempted to dwell too long upon the theoretical side, because a securing of facts involves observations covering great lengths of time and very careful study, and one becomes impatient.

"The paper presented by Mr. Manson discusses a subject of much interest to the student of meteorology. It treats of that branch of meteorologic science which is commanding the attention of leading meteorologists throughout the world. It touches the very foundation of our present theories as to the conditions of atmospheric circulation on the earth. In its application it is necessarily fundamental. We seem to know that the initial cause of

*This condition has been passed through by the earth, as geologically recorded in the fossil life of all latitudes. See Transactions Technical Society of the Pacific Coast; Vol. 8, No. 1, Sept. 1891.

motion in the atmosphere is solar heat. It is the present belief that we know, with a moderate degree of accuracy, the amount of heat which the sun radiates to the earth. It is also fairly well assumed that we know, in a general way, how the atmosphere acts in keeping the earth warm by letting the solar rays pass into it, and by keeping others back from the soil.

Professor Loomis states that the atmosphere is heated in three ways: By the direct rays of the sun; by contact with the warmer earth; and by the radiation and reflection of heat from the earth. A portion of the heat which the earth receives from the sun radiates into space. These rays are partly absorbed by the air, especially by its lower strata, and these strata, in their turn, diffuse invisible rays of heat in every direction. It has been usual to state that the extreme violet rays are not readily transmitted by our atmosphere; that of the light rays about one fifth are absorbed, and four fifths transmitted, while that as we proceed through the extreme red to the dark heat rays we find the absorption growing greater and greater, the dark heat rays being found in very small quantity because they are absorbed almost wholly.

To fully understand the effect of solar energy in producing motion in the atmosphere of the earth we must be able to measure the difference in effect between light heat rays and dark heat rays. We must also know what kind of heat is radiated from the soil. To gain this knowledge involves a measurement of the wave lengths of the different kinds of heat, which, as yet, physicists are not able to determine satisfactorily. Professor Tyndall has been able to show by actual experiment that to such kinds of heat as come from terrestrial sources of very low temperatures, vapors and gases known to be important constituents of our atmosphere were almost impermeable.

It seems reasonable to assume that solar energy affects, in some way, the atmosphere of all planets. Whether it be proper for us to reason by analogy as to motions in the earth's atmosphere from those supposed to exist in the atmosphere of some other planet, is a matter admitting of much discussion. The reverse of the proposition seems even more difficult when motions in the earth's atmosphere are analyzed upon a basis of assumed conditions in the atmosphere of the other planet. Professor Langley has shown, by his investigations into the subject of solar heat, that the action of solar energy in producing atmospheric circulation is a complicated one, requiring the most elaborate investigation to demonstrate. He says, 'In view of the large limits of area we can adopt three calories

as the most probably value of the solar constant.' By this is meant that at the earth's mean distance, in the absence of its absorbing atmosphere, the solar rays would raise one gramme of water three degrees centigrade per minute for each normally exposed square centimeter of its surface. This is approximately 126,550,000 ergs per square centimeter per minute. Expressed in terms of melting ice it implies a solar radiation capable of melting an ice shell 54.45 meters deep annually, over the whole surface of the earth. Somewhat less than two thirds of this amount reaches us at the sea level ordinarily from a zenith sun. But unless very great precautions are exercised we are apt to undervalue this directly received amount. It follows then that the selective absorption of our atmosphere is not only more diverse in kind, but that the total atmospheric absorption is far greater in amount than has been commonly supposed.

Although actual solar radiation is largely increased under a zenith sun, yet the temperature of the earth's surface is not due, principally, to this direct radiation, but to the quality of selective absorption in our atmosphere, without which the temperature of the soil in the tropics, under a vertical sun, would probably not rise above minus 200 degrees centigrade. Nearly all of the 215 degrees (the earth's actual, mean surface temperature being about 15 or 16 degrees centrigrade) of difference between this and the actual mean temperature of the planet's surface is due to this selective absorption which accumulates the heat.

The temperature of the earth, and with it the existence, not only of the human race but of all organized life on the globe, appears, in view of recent researches, to depend far less on the direct solar heat than on the quality of selective absorption in our atmosphere. The action of water vapor in modifying the effect of solar energy is a complicated one, the details of which we do not fully understand. In studying our own atmosphere we labor under the difficulty of living at the bottom of it. The variations of temperature with altitude has never been accurately determined. We are not able to measure accurately all of the elements that enter into the variability or the weight of our atmosphere. Our knowledge of cloud formation, and its effect upon solar radiation, and also terrestrial radiation is limited.

If all these difficulties have been encountered in the study of the earth's atmosphere for centuries, what must be the degree and reliability of our knowledge of the atmosphere of other planets of the solar system? Professor Loomis says that the sources of circulation in the earth's atmosphere may be defined under three heads, viz.:

1. Unequal atmospheric pressure.
2. Unequal specific gravity of the air.
3. The rotation of the earth.

As to the effect of the rotation of the earth, he says that its motion alone would produce no permanent wind, because, if there were no other disturbing causes, the atmosphere would, by a friction upon the earth's surface, soon acquire the same velocity of rotation as that of the portion of the earth upon which it rested. The earth's rotation, however, materially modifies the operation of other disturbing causes.

Professor Ferrel says that in considering the relative motions of bodies on the earth's surface, it is very important to take into account the influence of the earth's rotation upon such motions, and to not regard these as being the same, as the absolute motion in case of no rotation. If the earth were at rest, a body set in motion without friction on its surface would continue to move uniformly with its initial velocity. In case, however, of the earth's rotation upon its axis, this initial velocity becomes greatly modified, except perhaps at the equator. The effect of the heavy cloud formation over the equator in modifying the circulation of the atmosphere there, is quite ingeniously explained by Mr. Manson, and his theory seems a reasonable one.

We certainly cannot neglect the effect of the rotation of the earth upon atmospheric circulation, nor must we fail to appreciate the enormous influence of solar radiation. Just where to draw the dividing line, and properly assign to each important force its exact quota of influence, is a question of paramount importance in establishing the laws of atmospheric dynamics. I think, it must be said, that a thorough knowledge of the full effect of solar energy in this problem is of greater benefit in the solution of the practical questions of meteorology than would result from researches as to the influence of the axial rotation of the earth. I am glad to see that Mr. Manson realizes the importance of the greatest source of energy.

In regard to the atmosphere of any other planet outside of the earth, I am practically ignorant on the situation ; I do not know that anybody knows very much about it. We labor under a great difficulty from being at the bottom of our own atmosphere, not knowing much about what is going on above. If we could solve the problem of aerial navigation, it would do as much for practical meteorology as the telegraph has done. Were it not for the tele-

graph we would not be making any forecasts of the weather. I would certainly like to know something about the atmosphere of other planets ; but still it would seem hardly necessary to go beyond our planet in order to explain laws within our own atmosphere. Still, if a parallel exists, and is well founded, it would certainly aid in any discussion. I do not mean to neglect any element that can be brought in as a solution of the problems we have to contend with in both practical and theoretical meteorology."

MR. MANSON.—"When one masters the fact that solar energy is the sole cause of accelerating atmospheric circulation, and that without its action the atmosphere would lag behind, rather than keep up with the earth in its rotation, the prime law of wind movement is known. This law cannot be confined to one solar system, nor to one planet of any system, but is true for all planets —whatever the composition of their atmospheres may be. The movements of the cloud spots in the atmosphere of Jupiter are carefully observed and known, but the writer knows of no previous explanation of the cause and mode of action.

It is not necessary to draw particular lines of demarcation where one belt of wind stops and where another one begins. We might spend our lives in fixing the exact degree of latitude in which a belt of wind crosses a particular meridian. What is necessary is to get at the fundamental laws. We have to accept on faith the intricate and ingenious explanations given in the various works on physical geography. Even a sixteen-year-old school boy has put into his hands a set of explanations that do not explain, when the actual facts and laws are—as is always the case with Nature's ways—simple and plain.

Why the calm belt under the equator, between the two belts of easterly trades, should be accelerated so as to keep up with the enormous tangential velocity of the equator, was a subject requiring close study, and what produced that acceleration was a puzzle. But referring back to Prof. Maury's works on "Physical Geography of the Sea," and knowing that clouds intercept all solar energy—none passing through the cloud—the cause was found to be the intercepted heat, which must produce some effect in some direction."

MR. HILL.—"Mr. President, though not a member of the Society, I would like to say that I think this paper will probably be received with as much interest among those interested in astronomy as among those interested in meteorology. It certainly

is in the line of theories which have lately been advanced to account for very remarkable astronomical phenomena. A great many people have bothered their heads about the corona of the sun, but lately a theory has been offered to account for it; and the spots in Jupiter have puzzled all astronomers. If Mr. Manson's theory be proven by subsequent observation to be correct, it will be a great advance in the matter, and one we cannot fully appreciate tonight."

PROF. GALE.—"There is one point that is still a little cloudy to me, and that is, why the upper currents of the atmosphere should go in the same general direction as the lower currents; it seems that they go in directly opposite directions. I would like to know if there are any observations of the very high strata of atmosphere to show that they go in the same general direction as the lower strata."

MR. MANSON."—That is very easily demonstrated in the great dust cloud referred to; the dust was blown into the atmosphere by the explosion, a distance of not less than seventeen miles, and probably as high as thirty-one miles. Now, the direction of movement of the dust cloud after passing the belt of calms, was over Europe and North America *from the southwest.* Again, theoretically the atmosphere of higher altitudes ought to revolve in the same direction that it does in the lower altitudes, but with a less rate of speed; for this reason the upper strata intercept a smaller amount of solar energy by reason of their being more diathermous, consequently, in passing through these strata, heat rays produce less effect. But the resulting motion must be the same as at the surface, only differing in velocity; the general direction must therefore be the same in all latitudes and at all altitudes. Under the equator the cloud ring intercepts a greater amount of solar energy than anywhere else; a greater amount reaches it; consequently, westerly winds are more powerful there than anywhere else, but are neutralized by the greater tangential velocity of equatorial regions. The atmosphere in temperate latitudes revolves faster than does the earth, because proportionately more heat is taken up and heat must do work."

WE NEED A DEPARTMENT OF IRRIGATION ENGINEERING AT OUR UNIVERSITIES.

By C. E. Grunsky, C. E., Mem. Tec. Soc.

[Read June 3rd, 1892.]

The practical irrigator of the West has to an unusual extent been thrown upon his own resources. Experience has been his teacher. The methods he employs in the cultivation of his soil, in the application and control of his water, are generally the direct outcome of local experience. If methods are at fault, if his practice be bad, he knows it not. He looks to the immediate results, and if these be satisfactory, he is content. He may be doing himself untold injury, as when by systems of irrigation which involve upward movement of moisture from subsoil to surface, he causes an accumulation of the dreaded alkaline salts at the surface; yet he remains ignorant of the cause of the deterioration of his soil and continues the bad practice. Even when he recognizes the causes, he looks in vain for reliable authority as to the best remedy. Copious irrigation very often causes so great a rise of the water-table that drainage of soils becomes as important an element in the cultivation of crops as irrigation itself. The irrigator needs instruction and advice on this point; where shall he get it? Methods of irrigation should always be adopted after mature consideration, and should be dependent upon the available "head of water" upon topographical conditions, such as slope of the ground's surface, etc., upon character of soil and subsoil and the nature of the crop to be irrigated. It is not only important to adopt the best method of applying water, but it is equally important to irrigate at the right time and to avoid excessive use of water. The question is frequently asked and not easily answered: "What shall be the general method of irrigation when this canal system is complete?" In California accident has often shaped the answer to this question. Where the water-table was readily affected by the water sinking from canals and ditches, as in the King's River Delta, the method of controlling water-table elevations has found general acceptance; yet even today most of the irrigators in that section generally attribute the wetting of their soils to lateral horizontal percolation from their ditches. Wild flooding, or the spreading plan of applying water in the Kern River country, was soon found to be wasteful of the supply, and expensive by reason of the great amount of labor required to control the

water. It led to irrigation by flooding in contour checks, which method is admirably adapted to certain conditions of water supply, and to localities where the ground's surface has a fall of less than 20 feet per mile. Elsewhere, on surfaces naturally smooth with very light slopes, rectangular checks have been successfully substituted for contour checks, but these might prove failures under other conditions or in other localities. Furrow irrigation in all its forms, with and without drainage, has found application in many parts of this State, but its introduction on the Canal Farm, Merced County, on a large scale, early in the history of irrigation in San Joaquin Valley, proved a signal failure.

Where water for irrigation is limited in quantity, special precautions must be taken to avoid waste, and oftentimes only those portions of the soil are wet, where moisture will produce greatest benefits. A special study of conditions becomes necessary to attain the best results. Not less important than the question of method of applying water to land, is the study of soil treatment after water has been applied, and the frequency of irrigation under various conditions of soil character, depth of soil, topography, and crops cultivated. In determining what shall be the method of water application, or the practice of irrigation, the element of cost must be taken into consideration, cost of water, water rates or canal management, cost of ditching, cost of land preparation, cost of applying water, etc.

The constructing hydraulic or irrigation engineer of today is not expected to be a practical agriculturist or irrigator, much less a scientist: He is rarely qualified to give reliable advice on all these matters, even should he be called on to do so. His training is defective and provision should be made to remedy the defect.

The dissemination of thorough information on all these points, in the light of experience of irrigators in all parts of the world, not alone in one locality, or throughout one state, is desirable. Scientific investigation, study, and instruction are necessary. Such investigation, instruction and dissemination of useful information should be in charge of a properly constituted department at one or more of the universities of every state in which irrigation is practiced. In matters of this kind our universities should take the lead. They should be thoroughly equipped, as it is their especial province to point out and make accessible the lessons of experience that may be of special value for the advancement of human welfare.

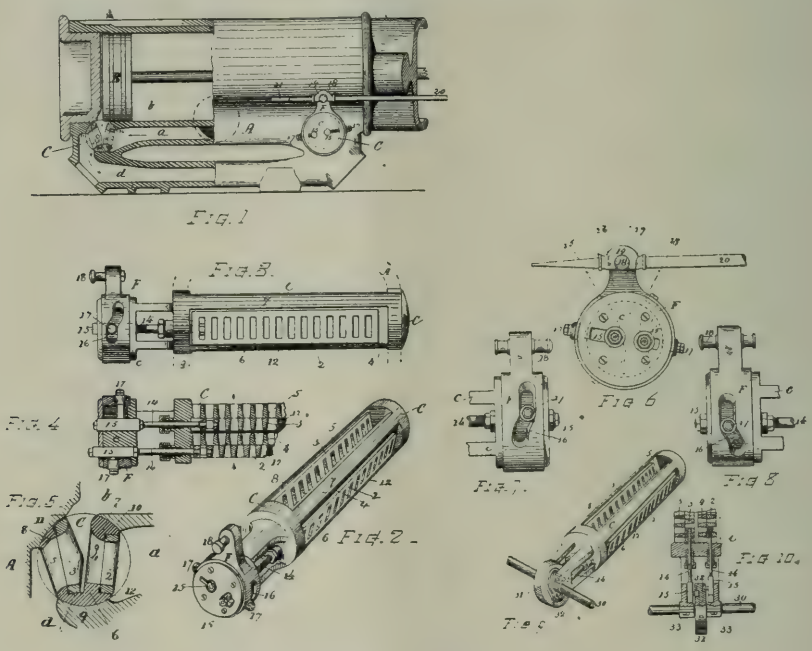
The departments of Agriculture or Irrigation Engineering, as already established in Utah and Colorado, are devoted to work of

this character. In no state is the need of such a department more keenly felt at the present time than in California.

Matters of purely agricultural interest, with irrigation in its bearings on agriculture as a secondary feature, are well looked after by the agricultural department of the State University at Berkeley, but that department should be supplemented, or combined with another, in which the engineering features of canal construction; control of water; development and storage of water; measurment of flowing water; water distribution and apportionment; loss of water in transit to lands, by percolation and evaporation; canal management; methods of irrigation and drainage; soil examinations; effect of irrigation on soil, climate, health and all kindred matters; can be made a specialty. Such a department might well be placed in charge of a professor of irrigation engineering, and it would certainly be as popular, as it is necessary for the proper development of our resources. I desire to suggest the establishment of such a department at a University of every state in which lands are irrigated, and particularly in California. It would be of immediate utility, and would result in the training of young men as specialists in the direction in which we at present see the greatest possibilities for development; in the direction of a change from ranching on a large scale, to the intense cultivation of the soil in small tracts by the contented farmer.

NEW ENGINE VALVE GEARING.

Mr. J. H. Hoadley, of the California Engineering Company, representing the Wheelock Engine Co., of Worcester, Mass., presented and explained a set, or system of engine valves.



NEW WHEELOCK ENGINE VALVES.

These valves are illustrated in the drawings herewith, in which:

Fig. 1 is a part side, part sectional view of an engine, cylinder and valves, illustrating the nature of the invention.

Fig. 2 is a perspective view showing, separate from the cylinder, the skeletonized plug or valve-seat frame with the inlet valve and exhaust valve.

Fig. 3 is a side view of the same.

Fig. 4 is a horizontal section through one end of the skeletonized plug, valves and valve-operating devices.

Fig. 5 is a transverse section through the valves and valve seats.

Fig. 6 is a front end view of the valve-operating mechanism.

Fig. 7 is a side of the rocker, showing its cam or groove for working the exhaust valve.

Fig. 8 is an opposite side view, showing its cam or groove for working the steam inlet valve.

Figures 9 and 10 show a modification in the cam mechanism, or operating parts, adapted for engines wherein a rotating shaft is employed, instead of an eccentric and rod for imparting movement to the valve-mechanism.

Mr. Hoadley's remarks were as follows :

"This valve was invented by Edward K. Hill. It is of new form and construction entirely. The valves are made in sets complete. This frame contains the entire valve mechanism. The cut-off and exhaust valve are on one side, and the live steam on the other side. In the Corliss engine the valves are at the four corners, so to speak ; these are at each corner below the piston. The Wheelock engines, as made since 1885, were mounted on a single block, an individual valve for each block, the valve moving up and down by means of links inside the cylinders.

The present valves are of the gridiron pattern. They give the greatest port area of any valve system. While the Corliss only has a port area of 7½ per cent. of the cylinder area, this engine gives about 18 per cent., which permits a full throttle pressure on the piston. No engine has ever accomplished that before, and of course this engine has ranked itself among the first in economy.

The main thing that this system was prepared for is marine work. A complete set of valves can be carried on board a steamer, so that an engineer can drive the old valves out and put in new ones without changing anything ; or he may easily remove the valve system and inspect or repair it, and replace it in a very short time.

This does away entirely with dash, or vacuum pots, that are necessary for their automatic engines. The valve is thrown back by steam pressure on the valve stem. There is a small spring in this model for the purpose. In a working engine this spring is not necessary.

For stationary work this engine is very desirable, especially for electrical apparatus. The valves will permit one hundred and fifty revolutions a minute, a speed that has never been attained by any other liberating valve gear ; the highest I have known is one hundred and two. With this valve gear, if you will notice, there is no movement required for the hook to catch hold of the block, as it merely drops about ⅛ of an inch.

The importance of this system is that it places makers of steam engines upon the same basis. It becomes a matter simply of quality and workmanship. All engines can be made to develop the same economy in regard to steam consumption. Manufacturers can buy the valve systems, bore the holes in the cylinder castings and press the valves in. The entire systems are all made by one concern, and furnished to different makers. There are six firms now that have contracted for the valves, intending to change from the Corliss method to this.

The importance of the cam movement is that these valves are never moved under pressure. It is not very easy to explain this without a personal observation. (Explaining on model.) While this exhaust port is moving, you will notice that the other does not; the pressure is on that valve now, and we see that the exhaust port is opening, letting the steam out of the cylinder all the time the exhaust port is open, and the live steam valve is stationary. The exhaust here is closed, and the live steam valve just ready to open. Now, while that opens on this side, the exhaust port has just been closed, and is stationary, so it is not moved under pressure. The consequence is that the valves operate very lightly and the friction on the engine itself is nominal.

Another important point is that this engine regulates itself perfectly, something I don't think any other engine has yet been made to do. The governor to give a full opening of the port has only to move ⅜ of an inch, and the least I have ever seen on a Corliss engine has been three inches for a full opening, or closing valve.

Another point in this is the securing of a slight throttle pressure, owing to this cam movement. The steam is let out in ample time without creating any back pressure at all on the piston.

There is yet another point: The fact of its being impossible to wreck the engine by getting water into the cylinder. It does not hurt the engine at all to get a flow of water into it, because in the absence of pressure inside — the exhaust port exhausts the pressure on the steam valve — this valve lifts from this side, and allows the water to escape. The valve can be lifted out four inches if necessary.

DISCUSSION.

Q.— "Can you give any comparative figures with Corliss engines as to economy?"

A.— "They will guarantee to excel all other engines five per cent. with this new valve. A comparative test has just been made in the East, between a compound engine of this class and a compound Corliss, and it excelled the Corliss 15 per cent."

Q.— "Do you consider the Corliss engine an economical, high-class engine?"

A.—"There are Corliss engines and Corliss engines, according as to how they are made. I do not suppose any automatic engine, so far, has beaten the Corliss engine except the Wheelock, because, up to date, these have been the accepted automatic engines."

PROF. GALE.— "I remember seeing a statement some time ago of a Corliss engine in the East running at the rate of 125 turns per minute."

MR. HOADLEY.— "The best that I know of in this respect is one at Providence, R. I., and that ran 102 turns."

Q.— "Is this engine in actual operation in this City?"

A.— "No. The first engines of this class that have been sent to the Coast, are three for the Albion Light and Water Co., at Portland, Oregon. There are two of the old style, gridiron-valve type, in use in the Chronicle Building."

THE PRESIDENT.—"I call upon Mr. Dickie for his opinion upon this subject."

MR. DICKIE.—"One of the remarks that has about 'paralyzed' me in regard to this subject is this: 'That the builders of marine engines would only have to bore four holes.' Now I hope that will not succeed. I will go out of the business when I merely have to bore holes, and receive the rest from the valve makers.

This valve, I have no doubt, is very good under certain conditions and for certain purposes. It may find a place, perhaps, for small engines. For marine purposes, and for very large powers, I do not think that that kind of mechanism is sufficiently substantial. The mechanism that operates the valve, slot, and roller, I am afraid, would wear rapidly in a very large valve. This system may be carried out in stationary work, but I think it can not be employed in marine work, because the conditions of the cylinders vary so immensely between one revolution and another, at sea in rough

weather; and all these devices, which are worked out very nicely, fail at the time when they are expected to be most effective.

I am prejudiced in speaking of this valve gear; I have seen many operated — I don't know how many, and I have tried to do something in this line myself, but, I am sorry to say, I had to give it up. I heard the same assertions made over twenty years ago, that it would only be necessary for a marine engineer to put up a frame work, bore the holes, and some concern will send the valve gear, and one engine will be as economical as another. I do not think that condition will ever obtain in regard to marine engines especially, that one will be as economical as the other. I have tried to make them alike and have found some economical, and others not, and we could not always tell the reason why.

The facility with which one can insert valve sets is a good point, but I was rather amused to hear that it would be necessary to stop at sea to do that sort of thing. As a rule a valve is pretty bad if you can't get into port with it, and it would have to be very bad indeed before permission would be given to stop at sea and take the valve out to look at it; it would have to be entirely useless before that would be allowed."

Mr. Hoadley.—"I referred to the general work of stationary engineering. I disagree with Mr. Dickie in the matter of the valves not being supplied to other makers, because I think this has already taken place. Competition through the eastern country is in such condition, that it means a great many failures, and a great deal of poor work; and it is putting the very best makers in the United States on a level with the lowest. One noted firm in the East, that I can mention, never went outside of their doors for an order until this time; now they cannot get enough work to keep their facilities employed, and work which they would not have allowed to go out of their place five years ago, they now try to believe is pretty good."

These valves can be made to almost any size desired, and much stronger than the example, (which is for a 12-inch engine), and all the dropping gearing comes away entirely. When arranged for marine use, it is a separate proposition altogether, and it is made very solid and substantial. I have been to sea a little myself. Mr. Dickie says that a valve would have to be very bad before permission would be given to stop. That is so, but if a valve is leaking so badly that several tons of coal are lost a day, it is

easy to run with a low pressure cylinder, when a valve can be taken out in a few minutes and another put into place."

MR. DICKIE.—"I think you underestimate the time. In removing a valve weighing half a ton, or a valve of an engine of any size, a few minutes do not amount to much."

MR. HOADLEY.—"You hold me exactly to what I said. I will say half an hour."

MR. DICKIE.—"I think that is a short time."

MR. HOADLEY.—"I can do it very easily in that time."

MR. DICKIE.—"I tried to get one out tonight at six o'clock. It was not out when I left. Valves are supposed to come out very easily, but when they have been used where there is salt water they are not apt to come out as readily as they went in. Driving metal to metal, it becomes locked together in a manner sometimes very difficult to separate. I have seen valves of the gridiron type—have made some myself—and I have a very vivid recollection of boring the whole thing out. And that, I think, would occur very frequently in a valve set like that, driven in metal to metal, and where salt water is apt to come in contact with metal surfaces."

MR. HOADLEY.—"I have had no experience with that valve on salt water, but I have had something to do with probably six hundred of these engines of the old style; that is, the exhaust on one block and live steam on the other block — a valve on each block— and I never had one stick yet, that I could not drive out with a little sledge hammer. Two blows would always take it out. I have never had any trouble at all when the engine was cool. They are bored on a taper and are readily removed."

MR. DICKIE.—"The conditions are entirely different with land engines; there the valves will remain in very much the same condition as when put in; but when they come in contact with salt water, I have met with considerable trouble in removing them. We have no difficulty with land engines, but with marine engines we have a great deal of trouble."

MR. HOADLEY.—"There are several preparations that can be put on them to keep the salt water from attacking them."

MR. DICKIE.—"We have gridiron valves in the "City of Pueblo," built by Cramp, who did not design the engines. They were designed by some one in New York. The engine is economical and has given very good results; but it has never repeated it — I do not know why."

REGULAR MEETING, JUNE 3rd, 1892.

PROCEEDINGS.

MINUTES.

The meeting was called to order by the President, John Richards.

The minutes of the last regular meeting were read and approved.

The following new members, having been balloted for, were declared elected:

John W. Gray, Hydraulic Engineer.....Oakland, Cal.
Mark B. Kerr, Civil Engineer.....San Francisco, Cal.
Prof. Willard D. Johnson, U. S. Geological Survey..Berkeley, Cal.
John H. Wallace, Civil Engineer.....San Francisco, Cal.

The following names were proposed for membership and referred to the Board of Directors:

For Members:

M. P. Boss, Mechanical Engineer, San Francisco, Cal.; proposed by Carl Stetefeldt, John Richards and H. C. Behr.

G. W. Sherwood, Civil Engineer, Riverside, Cal.; proposed by Otto von Geldern, H. C. Behr and Geo. F. Schild.

For Associate:

W. R. Phillips, Draftsman, Seattle, Washington; proposed by Hubert Vischer, H. C. Behr and C. E. Grunsky.

A communication was read from Mr. George G. Belmor, inviting the Society to witness certain tests to be made of a 56 horse power smokeless steam generator, made by the Belmor Smokeless Steam Generator Company of this City. The Society was asked to appoint a representative to be present during the time the boiler is undergoing the evaporative tests.

The President appointed a committee of three, consisting of Messrs. J. D. Isaacs (chairman), Carl Stetefeldt and H. C. Behr.

The following communication was read from the American Society of Civil Engineers :

New York, May 25, 1892.

OTTO VON GELDERN, Esq.,
Sec'y Technical Society of the Pacific Coast.

Dear Sir : — The American Society of Civil Engineers has accepted the duty of organizing and conducting the deliberations of division A, of the World's Congress Auxiliary of the Chicago Exposition. The subjects devoted to it are those relating to Civil Engineering.

The meetings of Division A will be held in Chicago, and, it is expected, will take the place of the Annual Convention of the Society for the year 1893. The sessions will be similar in all respects to the ordinary conventions, except that the deliberations will be participated in by engineers from all parts of the world.

Papers will be classified, advance copies, probably in abstract, sent to those competent to discuss them, and every arrangement made to add to the value of the proceedings.

It is not thought desirable to send out invitations promiscuously to write papers ; but that the best result will be reached by selecting men to write who have had special experience in particular branches of work, to be followed by discussions from others.

The object, therefore, of this circular is to ask your Society to name one of your members to aid the Committee of this Society having the matter in charge, by the suggestion of persons who are in position to furnish papers, which would be a credit to American engineering and of general interest to the profession.

Prompt action is desirable.

Yours Truly,
F. COLLINGWOOD, *Sec'y.*

This matter was referred, by a resolution, to the President for answer, and the following communication was sent in reply to the committee.

San Francisco, June 7, 1892.

F. COLLINGWOOD, Esq., *Sec'y Am. Soc. C. E.*
127 East Twenty-Third St., New York.

Dear Sir : — Your communication of the 25th ultimo, to the Technical Society of the Pacific Coast, has, by a resolution of that Society, been referred to the writer for reply.

In compliance with this resolution and your request, I will name Mr. C. E. Grunsky, C. E., Flood Building, this City, as a representative and competent engineer to coöperate with your committee in the matter referred to in your communication.

I am, Sir, Yours Very Truly
JOHN RICHARDS,
Pres't Technical Society.

Mr. Marsden Manson then read a paper entitled "The Circulation of the Atmosphere of Planets," which was discussed by Lieut. Finley, Chas. B. Hill and Professor Gale.

Mr. C. E. Grunsky read a communication to the Society, dwelling upon the practical usefulness of irrigation engineering, and the necessity of providing means of acquiring and disseminating knowledge in this science, and suggesting the creation of a Chair of Irrigation Engineering in our Universities.

Mr. J. H. Hoadley, representing the Wheelock Engine Co., of Worcester, Mass., exhibited to the members an improved form of a steam engine valve, which he fully explained in its details and manner of manipulation, answering all questions and criticisms by interested parties.

Adjourned. OTTO VON GELDERN, *Sec'y.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME IX. No. 6.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

A PROBLEM IN LAUNCHING THE PACIFIC MAIL STEAMER "PERU," AT THE UNION IRON WORKS.

BY HUGO P. FREAR, NAVAL ARCHITECT.

[Read July 1st, 1892.]

The problem of launching the Pacific Mail Company's Steamship *Peru*, now building at the Union Iron Works, San Francisco, rendered it desirable to make certain computations before laying the ways, and becoming interested in the subject the author decided to construct launching curves and scales for reading the technical conditions of the vessel from the time she started to move until she was water borne.

The problem which prompted him to make the curves is special, and while expecting to make it the feature of this paper he took particular interest in harmonizing the different curves and scales so that there would be a fixed relation among them, and in adapting them to solving any problem in the statics of launching.

In order that the reader may see clearly why the *Peru* was placed under her present conditions of launching, and better understand the problem, we will describe briefly our building slips, after which the article will be divided into two heads.

First.—The reasons and possibility of building and launching her under the present conditions.

Second.—The problem of launching her under the present conditions, both from an economical and technical standpoint.

The floor of our slips consists of a wharf, piled, capped and planked, which has an increasing inclination toward the water. There are permanent standards on each side of the slips which assist in carrying the staging for construction. They are spaced twelve feet apart, and support common roof trusses at the top, which span the slip-ways and support-tracks for overhead traveling cranes. Thus, it will be seen, that the vessel, if placed in one of our present slips, must be built under a permanent structure which has a limited height.

The reasons for placing the *Peru* under these conditions for launching date back several months before the contract was signed, and were entirely from an economical standpoint.

The wharf and structure overhead for a new slip sufficiently large enough to accommodate the *Peru* would cost about $40,000, and made the possibility of building her in one of our present slips a very important question to settle before taking the contract.

Over a year ago it was requested to make a profile of the only available slip we had, and lay in a vessel of the *Peru's* dimensions, and determine definitely whether she could be built and launched there.

This was done as requested, and I reported that it was possible, but that we would be very much cramped for room. There was barely height enough for the *Peru* to squeeze in, and launch at an inclination of a half inch to the foot. This allowed the fore foot to clear the edge of the wharf by six inches, while the top of the stem would pass along just under the lower chord of the rafters overhead, which, by the way, are in a plane also inclined toward the water one half inch to the foot. The minimum clearance on each side was only six inches.

We will now assume that the keel has been laid and the frames erected, and that the vessel will be launched in four months. This was about the time that instructions were given to determine how the piling would need to extend beyond the end of the wharf

for laying the ways. This information was wanted at this early date because there were other piles to drive, and the Superintendent, Mr. Dickie, wanted to have the work all done at once.

The problem, pure and simple, was to lay down a line for the launching ways:

First.—Such that the vessel in taking the water would not dip down at the stern, or tumble over the end of the ways, and consequently lift at the stem, and thereby carry away some of the rafters overhead.

Second.—For economy to drive as few piles as possible.

In other words, the vessel was to be got into the water as soon as possible without carrying away anything.

There are a few facts which must be known before making the calculations.

First.—The proportions of the vessel.

Second.—Exact position of vessel in relation to the wharf and superstructure.

Third.—Weight, and fore and aft position of the center of gravity of the hull.

Fourth.—Exact water level at time of launching.

Fifth.—To determine the launching line.

FIRST DIMENSIONS.

Length over all	346 ft. 0 in.
Length between perpendiculars	326 ft. 0 in.
Breadth	45 ft. 0 in.
Depth	27 ft. 6 in.

Second.—In obtaining the position of the vessel in relation to the wharf the work was done from her keel, which was straight except where it rounded up at the fore foot. A surveyor's level was used to determine the inclination of the straight part of the keel, which was 1 in 29.003, and then laid down her profile at the correct inclination. We then measured down from the keel to obtain the profile of the wharf, and measured up from the wharf and obtained the position of each rafter. It was necessary to make the measurements very carefully, as both the line of the wharf and rafters were very irregular.

Third.—It was not so easy to find the weight and center of gravity of the hull four months before launching, and it required considerable speculation, because no one could predict exactly what stage she would be in at that time. As an over estimate was on the safe side, because conditions entirely beyond our control had to be

dealt with. The following estimated weights were assumed, which would probably be aboard unless we were hurried in the launching.

Plates	2,166,507 pounds.
Bars and shapes	1,066,600 "
Stern post	13,000 "
Rudder	5,127 "
Keel	33,525 "
Stem	4,158 "
Deck Stanchions	34,988 "
Miscellaneous forgings	6,000 "
Cement	155,000 "
Rivet heads	60,000 "
Wood decks	367,500 "
Wood ceiling	180,000 "
Deck and ceiling bolts	10,000 "
Cargo port frames	8,000 "
Engineers' work	139,721 "
Paint	12,000 "
	4,262,126 pounds

or 1,903 long tons, which we will call 1,900 tons throughout our calculations.

For finding the fore and aft position of the center of gravity, and the distribution of weight, a curve was constructed, which we will call the curve of loads for hull. (Shown in the diagram.)

The vertical ordinates of this curve are on a scale of 250 pounds = one foot, and each ordinate, one foot apart, represents the weight of one foot of length of the ship in a corresponding position. The area of the curve equals the weight of the whole ship on a scale of 250 pounds to the square foot. Therefore the center of gravity of the area within this curve corresponds to the fore and aft position of the center of gravity of the ship.

This was found by the use of Simpson's multipliers. This method was chosen because it is simple, and, if desired, curves for shearing and bending stresses for any given position could be constructed.

Fourth.—The water level was not much easier to guess than the weight, because the tide varies every day, and the calendar tide is not always reliable to a few inches. The tide assumed was five feet, and the correct position of this is shown in the diagrams.

Fifth.—The launching line must be determined by trial. At this stage we knew the vessel could be launched at an inclination of half an inch to the foot. If she slid until the stem passed the last rafter

it was found by approximate figures that the stern was far from being water borne, and even if the stern was allowed to drop down, or over the end of the ways as in the case of most vessels, the piling for the ways would have to extend approximately 230 feet beyond the end of the wharf. This would require 230 piles at about $15 each, or $3,450, besides capping and timber for ways.

It was then decided to launch the *Peru* on a curved line. In determining the curved line the mean, initial inclination had to be settled, and be sufficiently great for the vessel to start. It was decided to make it 1 to 25 for the inclination of the chord on the length of the cradle at the starting position. As small inclination as possible at the beginning was desirable, because we could get a quicker curve, and that would enable us to reach the water sooner than a slight increase of inclination at the start.

At this point it became necessary to settle on the length of the cradle, and owing to the fineness of the ends of the vessel, found it impracticable to make them over 244 feet. We found a rise of arc of 12 inches on a chord of 244 feet, or the length of the cradle was as great as could be obtained, because with this spring the top of the cradle came within 2 inches of her bottom, and the underside of the ways rested on the lower end of the wharf.

At this inclination and curvature it was necessary to cut the forward chock down to the forecastle deck beams which would clear the rafters by 7 inches, and the fore foot also cleared the wharf by 4 inches. This would allow the vessel to settle 2 inches from the time her keel was laid until she was on the launching cradle, and still have 2 inches to clear the foot of the wharf. This is sufficient with our system of lashing the forward poppets, but gives a very small margin.

While we will keep on the safe side, and assume that our initial mean inclination is 1 to 25, let us state here, that again owing to the fineness of her ends we were obliged to place the center of the cradle 13 feet forward of the center of gravity of the hull, and that the inclination of the tangent to the curve at the center of gravity of the hull is 1 to 23.522. At this inclination and pressure per square foot, which is 2.688 tons on the estimated weight, there should be no question about the vessel starting.

While the curves and scales have a graphic as well as a real relation to each other, and for any given position of the ship the corresponding data can be traced to each, they will be divided into four groups, and those placed together which seem to have a closer

relation. In describing them we will take them up in the natural order of performing the work.

FIRST GROUP.

A.—Scale-measuring distance vessel has traveled at various draughts.

B.—Draught curve measured from top of keel.

C.—Buoyancy curve.

The fore and aft ordinates are measured in a horizontal direction, and the slight difference due to the curvature of the ways has been neglected.

The vertical ordinates of all the curves, except the one described and the draught curve, are measured from the top of the keel, because the displacement practically begins at this point.

The *Peru* slides 50 feet before she begins to displace any water, and this is made the zero point for the base or first scale *A* which measures the distance the vessel has traveled at various draughts until she drops off the end of the ways. Draw a vertical line from this scale at 50 feet from zero, and start the draught and displacement curves with their respective zero points in this line.

Then when the vessel has slid 50 feet she draws 0 feet of water, and displaces 0 tons of water. The vessel was slid down the ways, and vertical lines drawn from the sliding scale corresponding to each 2 feet of draught and the displacements calculated. At 177 feet of travel she draws 10 feet of water and displaces 245 tons; at 222 feet she draws 14 feet and displaces 680 tons, and so curves were constructed so one can read the draught and displacement for any intermediate points, as, for instance, at 13 feet 7 inches draught she has traveled 218 feet and displaces 630 tons. This happens to be a point in our curves which we will consider later on.

In finding the displacements at various draughts of water there was made an outline tracing of the hull and line of the ways, and the tracing was slid over the drawing in the direction of the water, and care taken to keep the line of the ways coinciding with that on the drawing, and the water line traced on for each successive 2 feet of draught up to 20 feet. The displacement was thus found (and also fore and aft center of buoyancy, which will be used in the next group of curves) by means of a planimeter and Simpson's multpliers.

The draught curve if inverted, and turned end for end, would correspond to the locus of the keel of the vessel, and therefore is a part of a circle until the 18.521 feet draught is reached, a point

which we will consider later. The depths for dredging for the launch were taken from this curve.

The scale of feet adjoining the draught curve measures the ordinates of that curve, and the scale of tons to the extreme right of the drawing measures the ordinates of the displacement curve. Reference to the drawing will show the scales to which each curve has been constructed.

SECOND GROUP.

In approaching the second group it will be again stated that the *Peru* is to slide on the ways until the water lifts her up at the stern so that her fore end will not lift up, therefore the vessel will pivot or hinge about the fore end of the cradle, and will just be ready to hinge when the moment of the ship acting down about the fore end of the cradle is equal to the moment of buoyancy acting upward about the same point. This is the critical point we are about to determine by means of our second group, which consists of

D.—Fore and aft position of centers of buoyancy.

E.—Moments of buoyancy about fore end of cradle.

F.—Moment of ship about fore end of cradle.

As stated above, the center of buoyancy for each successive two feet draught of water was found while using Simpson's multipliers for obtaining the displacements. In plotting the curve there was drawn fore and aft lines parallel to the keel, through points in the buoyancy curve corresponding to their respective draughts and displacements, and spotted the correct center of buoyancy for each, on its respective line. In obtaining the curve of moments for buoyancy the displacement in tons were multiplied, for each successive draught, by the distance respectively of their corresponding centers of buoyancy from the forward end of the cradle, measured in feet in a horizontal direction.

These products gave the moments in foot tons of the force of buoyancy tending to make the *Peru* hinge about the forward end of the cradle, or the pivoting point. The points in this curve are spotted on vertical lines drawn through the respective points in the curve for centers of buoyancy to a scale of one foot equals three thousand foot tons.

The moment of the vessel acting down about the forward end of the cradle is a constant quantity, and is equal to her weight multiplied by the distance of her center of gravity from that point, also measured in feet in a horizontal direction. As this moment is a constant quantity, its curve becomes a straight line as shown in the cut.

It has been stated that the *Peru* would be ready to lift up at the stern when her moment acting down about the forward end of the cradle is equal to the moment of buoyancy acting upward about the same point. The intersection of these two curves, or rather the curve and straight line, show exactly when this should occur, taking into account only the statical forces of still water acting on a ship without momentum. These conditions will be touched upon later.

THIRD GROUP.

The third group of curves consists of

First.—The points G of application of land-borne weights at the various positions in relation to the vessel, or the position on the vessel of the centers of gravity of that part of the weight carried on the ways.

Second.—The curve H showing the loci of these same points in relation to the wharf as they move along with the vessel, and which show the various positions where the weights, acting through these points, are carried on the supports under the ways.

Third.—Curve J for determining the maximum length of ways for fulfilling certain conditions.

It is evident that if the vessel weighs 1,900 tons, and a part of that weight is carried by the buoyancy of the water, the balance of the weight must be carried on the ways or the earth; and the center of effort on the ways must be forward of the center of gravity of the vessel, a distance equal to the buoyancy multiplied by its distance aft of the center of gravity of the vessel, divided by the weight acting on the ways for a given position; or let W = weight of the vessel, D = the force of buoyancy, $W - D$ = land-borne weight, Y = distance D is aft of W, X = distance $W - D$ is forward of W. Then $Y D = X (W - D)$, or $X = \frac{Y D}{W - D}$

From the curves already plotted, D and Y are known; $W - D$ is also easily found, and therefore the value of X can be found for any position, and the curve plotted for the amount and point of application of the land-borne weights.

The land-borne weights vary from 1,900 tons to 0, as the vessel takes the water.

The abscissæ of this curve are measured forward of the vertical drawn through the center of gravity of the vessel, on lines passing through corresponding points in the displacement scale. The scale of tons to the right, measures the buoyancy up to any given one of these

lines, and the balance of tons measured on this scale measures in tons the ordinates of the curve for land-borne weights. Therefore, if this scale of tons is inverted, it would give the correct reading of land-borne weights in tons, for any data selected from any of the other curves or scales already described; as, for instance, when the *Peru* has traveled 268 feet, she draws 18.521 feet of water, and displaces 1,475 tons; the center of buoyancy and center of land-borne weights are then shown by the curves, and the land-borne weight is 425 tons, as measured by the scale to the right and adjoining this curve. This curve shows the center of weights in relation to the ship, each of the points being, as it were, fixed with the vessel. The distance each of these points has traveled can be readily traced to the scale *A*, before described.

If each of the points are moved aft, as far as the vessel has traveled, as read from the scale just referred to, and a curve *H* drawn through them, this curve would show the points of application of land-borne weights in relation to the end of the wharf.

The vertical ordinates of this curve are equal to the respective draughts of water, as measured by the scale to the extreme left. This scale is four times as large as the first draught scale described, so the curve would not be too flat to read accurately.

The next curve *J* is for the purpose of determining the end of the ways. It was decided that the ways should be of such a length that no pile supporting them should be allowed to carry over 14 tons until the vessel lifted at the stern. This curve is constructed to exactly fulfill this condition at each point. Each launching way is supported by a pair of piles every four feet, and as there are two launching ways, there is an average of one pile per running foot of ways, and consequently under the above condition there would be a load of 14 tons per running foot of ways.

The curve *H*, described above, shows where the center of land-borne weight is carried for each position of the vessel. In distributing the weight over the ways, half would be carried forward and half aft of the center of application on the ways.

Therefore, if the weight for each point was divided by 2, and again by 14, the quotient would be the number of running feet of ways aft of the center of weight for the given position of the vessel; or let $W - D$ = weight for any position, then $\frac{W-D}{2 \times 14}$ would give the number of running feet of ways aft of any given point on curve *H*, and a curve *J* drawn through these points would determine the

end of the ways for fulfilling the above condition for any position of the vessel, and the point to the extreme left of this curve shows the minimum length of ways for fulfilling the conditions of 14 tons per pile, for the position of the vessel producing the greatest weight on the end of the ways, before she lifts at the stern.

It will be noticed that the *Peru* is drawing 13 feet 7 inches of water at this point. She has traveled 218 feet, weighs 630 tons in the water, and 1,270 tons on the ways. At this point, curve *G* is just beginning to change from nearly a straight line to a pronounced convex shape, which shows that the center of land-borne weight is beginning to travel forward much more rapidly in its relation to the ship. Curve *H* shows that this center of the land-borne weight is fast approaching a point where it travels forward on the vessel at a velocity equal to the speed of the ship, or where it becomes instantaneously stationary as far as its actual speed over the ground is concerned.

Here the displacement is increasing so rapidly, and the land-borne weight is decreasing at the same rate, so that the distance between the two curves *H* and *J* is decreasing faster than the points on *H* are traveling aft; and that is why the maximum length of ways is required earlier than when the center of land-borne weight is at its greatest distance from land.

This ends the problem of the paper proper, namely, to find the minimum length of ways for a load of 14 tons per pile, until the vessel is lifted at the stern. But it would be hardly right to stop here without constructing our curves until the cradle on which the vessel rests, is entirely clear of the ways.

All the curves have been constructed thus far, up to the point where the vessel lifts at the stern. The scale *K*, at the extreme bottom of the cut, shows how much of the cradle remains on the end of the ways at this point. The zero point is placed at the extreme right, or under the point where scale *A* indicates that the cradle drops from the end of the ways.

The scale is, of course, 244 feet long, or equal to the length of the cradle. The 244 foot reading is the point where the after end of the cradle has just reached the after end of the ways. Scale *A* shows that the vessel has traveled 132 feet up to this point, and any of the vertical lines drawn through scale *A* to scale *K* will show the length of cradle remaining on the ways for any particular distance the vessel has traveled.

Thus when she has traveled 268 feet, or the distance where she begins to lift at the stern, scale K indicates that there are 108 feet of cradle remaining on the ways.

The curves up to this point have been constructed on known draughts. After this the displacement and center of buoyancy is determined before the exact draught is known. From now on the moment of buoyancy and moment of hull, acting in opposite directions about the forward end of the cradle, will be equal with the forward end of the cradle resting on the ways, until the vessel drops or floats off. The draught of water must be such that the above conditions will be fulfilled.

Slide the vessel down the ways with the upper end of the cradle resting on them and find the displacement, center of buoyancy, and moment of center of buoyancy for three different draughts of water within limits between which the draught required will probably fall. Draw trial curves through these points, and then the exact center of buoyancy, displacement, and finally the draught of water for fulfilling the conditions of equilibrium can be traced from the point where the trial curve of moments for centers of buoyancy intersects the line of moments for hull. This process is gone through with for as many points as are desired for constructing the above curves. The method of constructing the other curves is the same as already described.

The most important curve from here on is that for the land-borne weights. The whole of this weight theoretically comes on the forward end of the cradle, but practically the forward poppets crush down from one to three inches, and better distribute the weight.

Curves H and J show that the greatest weight comes on the ends of the ways just before the cradle drops off. The only way to obviate this is to build the vessel more nearly in the trim she will assume after she is launched. Shallow, full-ended boats have often broken their backs because they were built at too great an inclination.

The work described, a great deal of which is of a speculative nature, was performed three months before the vessel was launched. The above, too, was written before the launch, because it was thought that the steps and uncertainties which led to it would be more interesting than a bare description of curves constructed when the data consisted entirely of known quantities.

It would be interesting to note the difference between estimated and actual results.

First.—The *Peru* was launched the 11th of June, 1892, at eleven o'clock at night, instead of the middle of July.

Second.—She only weighed 1,680 tons, instead of 1,900 tons.

Third.—She cleared the rafters 12 inches instead of 7 inches.

Fourth.—The tide did not come up within fifteen inches as high as there was every reason to expect. It happened that the tide rose to within half an inch of where it had been assumed, and although it was a calm bright moonlight night, the tide was fifteen inches lower than recorded two or three weeks before, for the same calendar tide, under conditions apparently less favorable.

Fifth.—The pressure per square foot of greased surface was only 2.376 tons instead of 2.688 tons.

Had the *Peru* remained in the slip a month or five weeks longer, she might have weighed 1,800 tons, or 100 tons less than the weight used throughout our calculations. This overestimate will seem excessive to those unaccustomed to building and launching ships over piles driven in soft mud.

The *Peru* settled 2 inches on the keel blocks while building, and she settled 1¾ inches at the stern, and 1¼ inches at the stem, during the last two hours before she was launched, and perhaps the piling settled enough more to cause her to clear the rafters 12 inches instead of 7 inches. She only cleared the foot of the wharf by half an inch instead of 4 inches.

There were only two ways of being on the safe side. One, to over estimate the weight, the other to come closer to the weight and then drive a few extra piles.

After these calculations were made, and before the piles were driven, we hoped to get at least 6 inches more water than had been assumed, even if we had to launch at midnight. It was also decided to stop the piling 28 feet short of the calculation, and from that point build a mud raft or crib 16 feet beyond the projected extreme ends of ways for supporting them. This was almost as good as piling because the outer end was elevated 23 inches, and had to be depressed that amount before the vessel could pass; the drawing shows these alterations. We have been accustomed to launching over a mud raft for cushioning, as the vessel tumbles over the end of the ways. This relieves the vessel of strains which are sometimes serious, and prevents the grease from being cut at the end of the ways, and causing the vessel to stick. Where the vessel is to "hinge up," as in our case, the mud raft is of use only for lengthening the ways. A rigid point at the end of the ways is no

objection because the weight is lifted here, and comes on the forward end of the cradle. If it were possible to well cushion this point, it would be an advantage.

The curves F_1, G_1, H_1, and J_1 have been altered for the correct weight of the vessel, and are shown in dotted lines. The curve J_1, shows that the mud raft could have been dispensed with if the piles had extended nine feet further from shore. In conclusion, it will be said that in making the calculations the momentum was ignored for two reasons. 1st., because there was no data. 2nd., it could not affect the length of the ways in our special case, because according to the curves, the maximum length of the ways is required when she has traveled 218 feet. The calculated lifting point is reached when she has traveled 268 feet, and the length of ways required to fulfill the statical conditions of 14 tons per pile could be 82 feet, less than the maximum, at the point where she lifts up, consequently, even should her displacement remain constant, she could travel on in the same circular direction 82 feet and still weigh only 14 tons per pile. The stem would continue in the same circular locus until the stern lifted, as it inevitably would. The only difference would be a little more draught of water, which is of no consequence with our soft mud for a bottom.

The *Peru* was making over 10½ knots per hour, or about 18 feet per second, and so her momentum must have been a considerable quantity, and if she actualy lifted where the curves said she would, the total energy of the wave at that time would, presumably, just measure the momentum. A curve of speed at the various positions during the launch has been placed on the drawing.

REGULAR MEETING, JULY 1st, 1892.

PROCEEDINGS.

MINUTES.

The meeting was called to order by the Chairman, Mr. C. E. Grunsky.

The minutes of the last regular meeting were read and approved.

The following new members, having been balloted for, were declared elected:

For Members:

M. P. Boss, Mechanical Engineer..... San Francisco, Cal.
G. W. Sherwood, Civil Engineer.....Riverside, Cal.

For Associate:

W. R. Phillips, Draftsman.....Seattle, Wash.

The following names were proposed for membership, and referred to the Executive Committee:

Wm. H. Saunders, Civil and Hydraulic Engineer, Pomona, Cal.; proposed by P. J. Flynn, Burr Bassell and H. C. Behr.

Edward Lownes, Civil Engineer, Riverside, Cal.; proposed by P. J. Flynn, Chas. H. Congdon and J. R. Mauran.

Wm. Praun, Architect, San Francisco; proposed by Adolph Lietz, C. E. Grunsky and Otto von Geldern.

The President sent in the following communication:

"Mr. Andrew Fraser, a mining and mechanical engineer, of this City, member of our Society, a great, noble-hearted man in the prime of life, a friend of all who knew him, distinguished in his profession and in all connections—was foully murdered, supposedly by a native guide, between Chihuahua and a mining district two hundred miles distant in Sonora, Mexico, while traveling on business for the Risdon Iron Works, of this City, where he had been connected for several years past. He was fifty-four years old. His loss will be mourned by a wide circle of friends, here and elsewhere."

Upon motion the Chair appointed a committee of three, consisting of Messrs. R. S. Moore (chairman), L. C. Russel and E. A. Rix, to draw suitable resolutions of respect in memory of the member whose useful life had been so suddenly brought to an untimely end.

Mr. Hugo P. Frear, chief draughtsman of the Union Iron Works, then read a paper entitled "A Problem in Launching," in which he discussed a method employed by him in completing the necessary arrangements for launching the steamer *Peru*, recently built at the Union Iron Works. A large diagram illustrated the problems involved. Upon motion a vote of thanks was passed for the author.

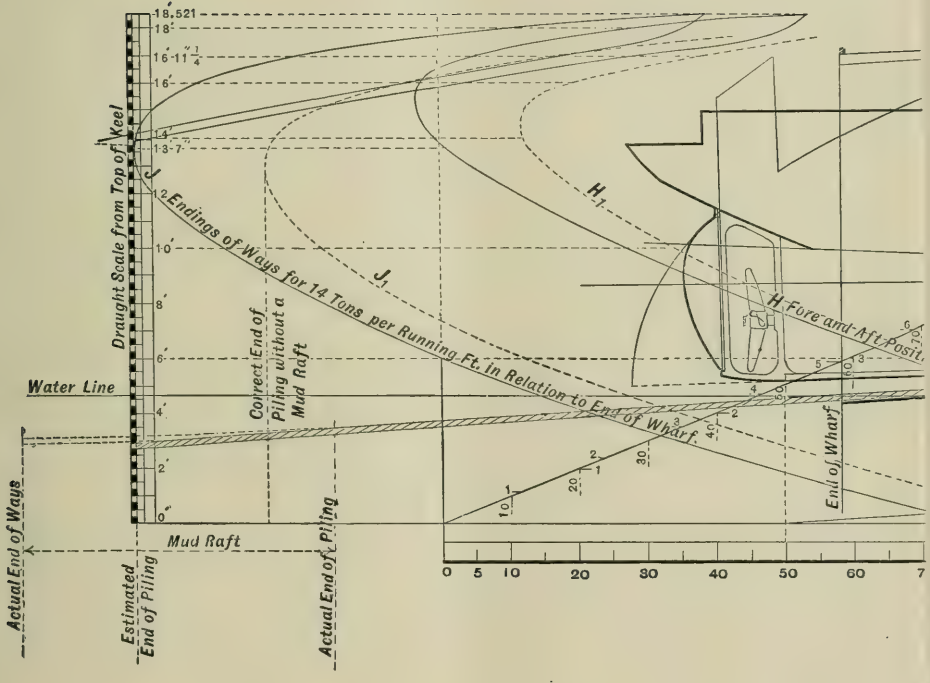
Adjourned. OTTO VON GELDERN, *Secretary*.

Technical Society of the Pacific Coast

"A Problem in Launching"

by

Hugo P. Frear

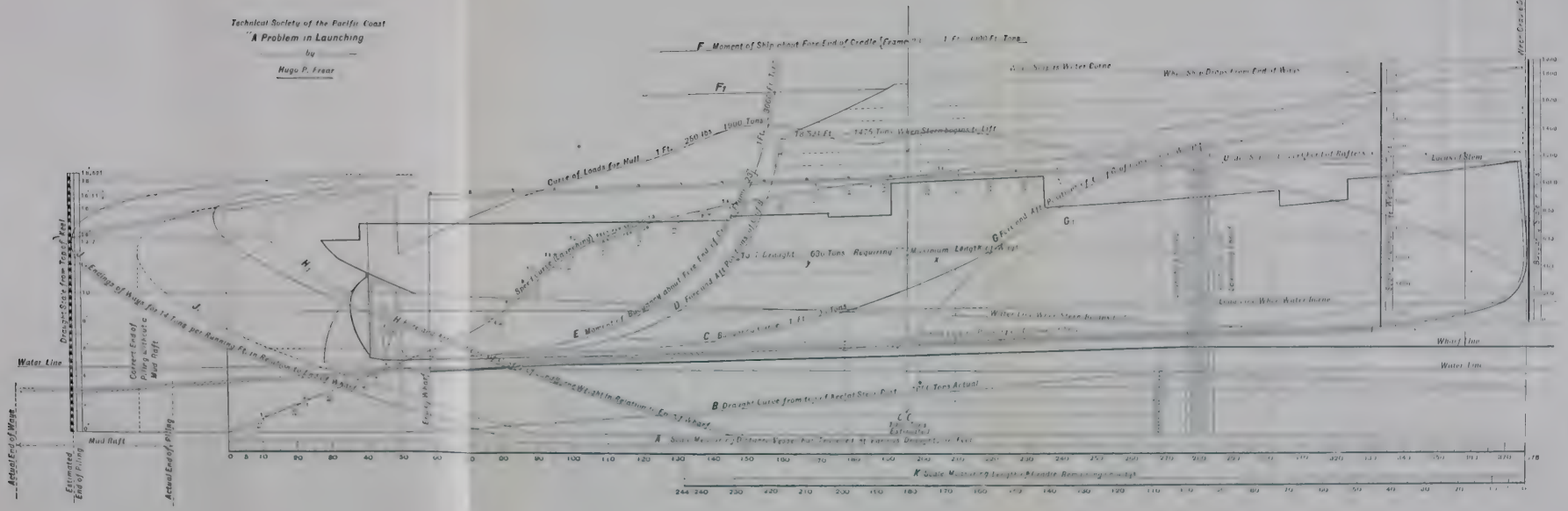


Technical Society of the Pacific Coast

A Problem in Launching

by

Hugo P. Frear


F Moment of Ship about Fore End of Cradle
Ft
Curve of Loads for Hull
Safe Curve (Launching) ... Ft.
D Fore and Aft Position of Ship
E Moment of Buoyancy about Fore End of Cradle
C Buoyancy
B Draught Curve from Actual Sinkage Test
A Scale Measuring Displacement
K Scale Measuring Length of Cradle
Water Line
Actual End of Ways
Extended End of Ways
Actual End of Piling
Mud Raft
Current End of Piling without Mud Raft
Ends of Ways for 14 Tons per Running Ft. in Relation to End of Wharf
Draught Scale from Keel
Wharf Line
Water Line
Lower Deck
Upper Deck
Lucas Storm
Mean Cross Sections from Keel

TECHNICAL SOCIETY OF THE PACIFIC COAST.

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CORLISS ENGINES.

BY J. B. PITCHFORD, Mem. Tech. Soc.

[Read August 5th, 1892.]

In speaking of Corliss Engines it is generally understood that the term refers to an engine with a cylinder having four rotary valves, one at each end, to regulate the steam admission, and one at each end for the steam outlet.

The first successful combination of four rotary valves applied to an engine in this way was made by George H. Corliss, some forty years ago. Rotary valves had been used by James Watt, on engines by Bolton & Watt; and Newcomen's engine must have had a single rotary valve, for it is recorded that in the year 1713, a boy named Humphrey Potter, whose duty it was to open and close one of these valves at each stroke of the engine, found it monotonous, and to save himself trouble devised a method of opening and closing the valve by means of tappets receiving their motion from the beam of the engine.

Although the Corliss engine has been in use for the past forty years, there have been but slight changes made in the main principles governing the valve motion. Since the expiration of the patent, Corliss engines have been adopted by many of the leading engine makers in the United States and in Europe, and they still continue to make them in preference to automatic engines of other kinds.

After the verdict of so much practical engineering talent in favor of this kind of valve gear, it would seem that there was hardly a possibility of obtaining anything to supersede the fundamental principles upon which it is devised.

The requirements of a valve gear for a steam engine is to let the steam into the cylinder at the proper time, to cut the steam off at any required period of the stroke, and to let the steam out at or near the termination of the stroke; to have the opening and closing orifices as close as possible to the piston, and at the same time to have these orifices of sufficient size so that the steam will not be reduced in pressure by wire drawing before the cut-off takes place, no matter what the piston speed may be.

It is evident that the orifices or ports can be much smaller with slow piston speeds than with high piston speeds, so that in making comparisons in regard to the clearance space between the valves and pistons of engines, the piston speed and length of stroke should be taken into account. The Corliss valve gear has other advantages besides that of comparatively reduced clearance. On account of the angular position of the pins to the rock plate, there is an accelerated and retarded movement imparted to the valves, and the connections are made so as to take advantage of this movement and thereby obtain a rapid opening of the valves at the early part of the stroke.

Having separate ports for the steam inlet and exhaust outlet must be advantageous, because the incoming steam does not have to pass through exhaust passages which have had their temperature reduced about 100 degrees below the initial steam.

Separate steam and exhaust valves having separate connections admit of considerable adjustment, especially if there is a separate eccentric for the exhaust valves. The steam chests are not excessively large, as on some slide-valve engines, and the valves are not as cumbersome, neither do they take as much power to move them as an unbalanced flat valve of any kind. Theoretically speaking, they only touch the valve seat at a line along the edges of the port when under pressure.

One of the first Corliss engines that came under my notice, twenty years ago, at Virginia City, Nevada, was made by Goss and Adams, of Sacramento, from drawings obtained from Mr. Corliss. It had been running about fifteen years, and at that time we had no mineral oils or valvoline, but tallow was used to lubricate the valves. The salts and acids of the tallow attacked the valve faces of all engines, and those that were run intermittently would wear very fast. The valves in this engine were at that time a sixteenth of an inch smaller in diameter than the hole in the steam chest, yet when the valves were closed and the indicator cocks opened, they did not leak. This shows that the point of contact at the port edges was steam tight.

It is concluded from this that if the valve was tight under these conditions, and it moved easier than a slide valve giving the same opening, that the Corliss valves could be made to move with less friction than unbalanced slide valves. The size of this engine was about $24'' \times 60''$, as near as I can remember, yet the valves could all be moved easily with the starting bar.

The Corliss valve motion has also the reputation of governing the engine steadily under varying loads. It is done by a releasing mechanism in most cases, and the point of release is determined by a little cam, the position of which is changed by the action of the

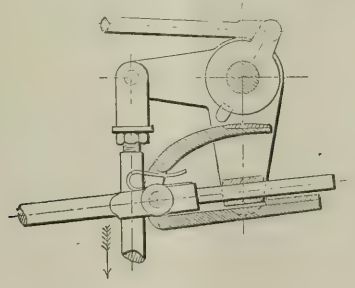

FIG. 1.

HARRIS–CORLISS VALVE GEARING.

governor. One of the first forms of this releasing gear was termed the crab-claw releasing gear, as shown in Fig. 1. It is very effective, and an improved form of it is still used by William Harris, one of the best Corliss engine makers at the present time. Before the introduction of the suction dash pots, the valves were closed by plate springs, the shock being taken by air dash pots regulated with adjustable plug cocks.

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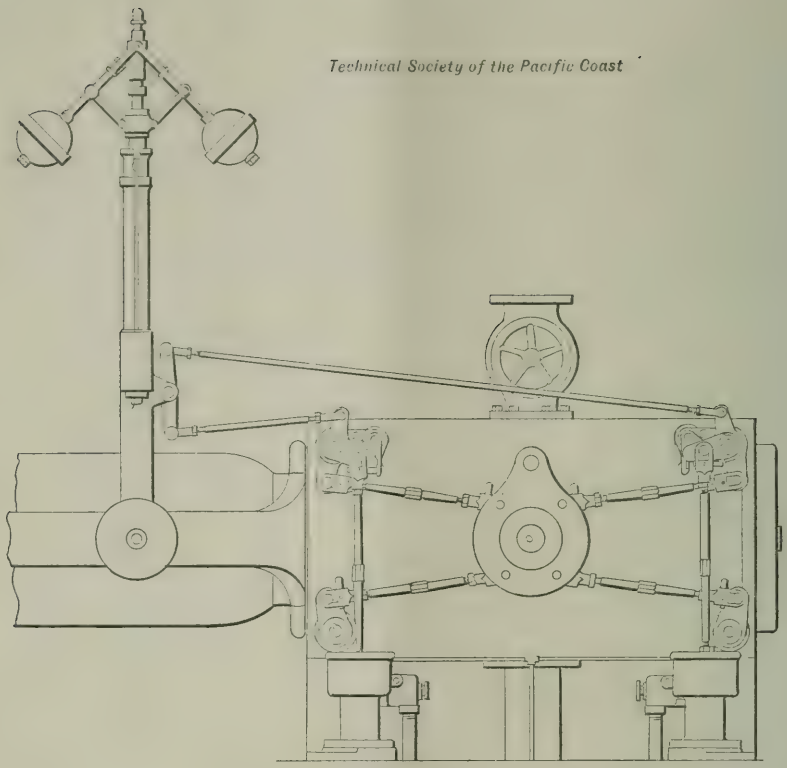

FIG. 2.

PITCHFORD–CORLISS VALVE GEARING.

Fig. 2 shows the hook releasing gear as used on the Reynolds-Corliss, Hamilton-Corliss, and others; but there are several kinds of releasing gear used by other Corliss engine makers. I understand that the George H. Corliss Co. have a new form of release gear, also a modification of the rocker on the cylinder, which gives an alternate accelerated and retarding motion to the valves, also a new application of relief valves.

Some makers of Corliss engines now arrange their pendulum governors with safety devices, so as to shut off the steam in case the governor belt breaks. It is the writer's opinion that belts for driving governors are a little behind the times, and that but a short time will elapse before the leading engine makers will dispense with them. Several large engines have been wrecked in consequence of governor belts breaking or slipping.

Most Corliss engine makers have adopted a modification of the girder frame introduced with the first Corliss engines, some of them using flat guides and some of them retaining the original V guide. Some of these frames have been built without a holding-down foot at the end of the guides, and this is found to be a defect in instances where the engine was run up near its full capacity. This form of frame will require to be strengthened if used for engines running over 100 revolutions per minute, and doing hard work. A frame with circular bored guides has the advantage of allowing the cross-head to run free if the engine shaft is not horizontal. The author has found a modification of the Porter-Allen frame to be well adapted for high speeds.

Some Eastern makers of engines retain the small sizes adopted, for crank pins, cross-head pins, and valve-gear pins, when it was customary to run at lower speeds. This cheapens the work, but it is evident that an engine with small wearing surfaces cannot last as well doing heavy work as one with ample surface, and as the tendency is now to increase speeds the surfaces will also have to be increased.

The August issue of the Magazine *Industry*, shows that Mr. S. S. Webber, of the Trenton Iron Co., has written a letter telling of a $20'' \times 42''$ Corliss engine having a releasing valve gear, and running at a speed of 160 to 170 revolutions per minute. This is something extraordinary for a releasing gear. I should have thought it impossible to avoid the shock that apparently would be caused by the sudden contact of a moving part coming at a high velocity against the inert mass represented by the valve when disengaged. If Corliss engines can be run successfully in this way to suit general manufacturing purposes, it is strange that the Corliss Engine Company, and other makers, still continue to rate all their engines at speeds below 100 revolutions per minute.

Since the introduction of electricity there has been a demand for higher speeds with economical engines. The difficulty that presented itself was to obtain both results with the same engine. There are plenty of high-speed engines that fail when it comes to a comparison of economy with a good Corliss engine.

We do not depend upon isolated tests under some peculiarly advantageous circumstances, to illustrate the durability and economy of well-made Corliss engines, there are at least a score of first-class engineering firms who can produce records of tests, made by unbiased competent engineers, of engines they have made. And

RESULTS OF CORLISS ENGINE TESTS.

Name of Maker.	Tested by	1st Cylinder.	2nd Cylinder.	3d Cylinder.	Revolutions per Minute.	Steam Pressure.	Pressure in 1st Receiver.	Vacuum.	Duration of Trials, Hours.	H. P. Developed—1st Cylinder.	H. P. Developed—2nd Cylinder.	H. P. Developed—3d Cylinder.	Total Horse Power.	Lbs. Coal per Indicated H. P.	Lbs. Water per Indicated H. P.	Remarks.
Wm. A. Harris	Geo. H. Barrus	22x60	44x60		68	113	8	25.6	60	312	307		619	1.69	*14.31	Tandem. *Includes 600 lbs. Water for Jackets.
Wm. A. Harris	John W. Hill	16x48				74.4			8				72.3	2.57	23.13	High Pressure.
Watts, Campbell Co.	John Young	20x48	36x48		64	80		27	96				297.5	1.73		Tandem Compound.
Reynolds	E. D. Leavitt & Henthorne	14x48	25x48	33x48	99.1	125		26.5	10				515.7		12.94	Jacketed Cylinders. Independent Condenser.
Reynolds	Remington & Henthorn	18x42	32x42			98				109.6	124.1		233.7		13.26	Cross Compound.
Reynolds		19x48	38x48			102		26	24				325.4		14	Jet Condenser.
Reynolds	B. H. Fiend	27x60	46x60	70x60	16.6	124	25.8	27	8	389					12.67	Triple Pump Engine Jacketed.
Payne		20x28			120									2.64		High Pressure.
Corliss Steam Engine Co. Providence, R. I.	Richard Borden Mill Fall River	20x60	34x60	two 36x60	65.8			27.3	61.4	353.54	329.78	two 380.13	1063.	1.445		Triple Expansion. Four Cylinders. Double Tandem.

it is shown that Corliss engines, about 18″ × 48″, running at 600 feet piston speed, can run high pressure on from 20 to 22 pounds of steam per indicated horse power per hour, and on 16 to 17 pounds of steam when condensing. Engines of this size are built with clearances of from 2 to 2½ per cent. between the valves and the piston. The Watts-Campbell Co. say their high-pressure Corliss engines will run on 3 pounds of coal—2¼ pounds condensing; $1\frac{7}{10}$ pounds compound condensing, and 1½ pounds triple expansion.

There is subjoined a list of trials of Corliss engines, which were obtained hurriedly, and do not set forth as being the best obtainable; it will be observed that a triple-expansion Corliss engine has developed a horse power on about $1\frac{44}{100}$ pounds of coal per horse power per hour. This is coming near to the best results of the best type of triple-expansion marine engines, whose records are generally made under more favorable circumstances than land engines, in consequence of the proportions of the cylinders being made to suit a uniform boiler pressure, with the uniform resistance of a propeller acting as a hydraulic brake, and tested generally with the best kind of coal.

The transatlantic marine engine practice, during the past twenty years, shows that the right road to economy in the use of steam is by making triple-expansion and quadruple engines. These eminent engineers of extensive experience evidently add additional cylinders for the purpose of maintaining equable temperatures, and this is following the advice given by James Watt, who did more than any one engineer to enunciate the fundamental principles of the steam engine. He said: "keep the cylinder as hot as the steam that you are going to put in it," and it is evident this is not done when an engineer undertakes to make too many expansions in the same cylinder, and it demonstrates that with high pressures, triple expansion must be preferable to two cylinders, and that steam jacketing is one of the essentials.

The duty of pumping engines has been increased materially by the introduction of the Corliss valve gear. A high pressure geared pumping engine at Madison, Wisconsin, has a record of over 71,596,000 pounds raised one foot high with 100 pounds of coal. The compound condensing pumping engines at Milwaukee have a record of 104,820,431 pounds raised one foot high. It was somewhat surprising to learn that this method of rating the duty of pumping engines was introduced by Bolton and Watt over 100 years ago, the only difference being that they used the English hundredweight of

coal, 112 pounds. It appears that they were paid in proportion to the coal their engines saved.

It is noticeable in most branches of engineering that whenever it is essential to have a really first-class economical steam power, that an engine having Corliss valves is selected. The large Ingersoll-Sergeant duplex air compressors are run by Corliss engines. The largest refrigerating machine, built by the De La Vergne Refrigerating Co., is driven by a Cross compound Corliss engine, 32″ and 64″ by 48″ of 600 horse power. The Frick Co. furnished a 750 horse power, tandem compound condensing Corliss engine 30″ and 44″ by 48″, for the Tacoma Electric Railway and Motor Co. It has a fly wheel 25 feet diameter, weighing 50 tons, and runs 65 revolutions per minute.

A Harris-Corliss compound steam engine at Fall River, Mass., is 28″ and 52″ by 72″, and runs 56 revolutions per minute, with a fly wheel 30 feet diameter, and 96 inches face. The steam pressure is 125 pounds, the rated horse power 1,100, and the rim speed of the wheel is 5,281 feet per minute. The Corliss Steam Engine Co. have made a quadruple expansion engine coupled at right angles, with 24″ and 52½″ cylinders on one side, and 36″ and 64½″ cylinders on the other side, arranged tandem. The fly wheel is 32 feet diameter, 114 inches face, and makes a rim speed of 5,278 feet per minute.

It appears to be the practice with some makers of Corliss engines to make their fly wheels weigh from 80 to 100 pounds for each horse power developed by the engine when cutting off at one fourth stroke with 80 pounds of steam. The Philadelphia Engineering Co. advocate 150 pounds of metal in the rim of fly wheels for electric railway engines, 75 to 100 pounds for electric light engines. Of course, it is understood that the rim weight can be reduced with tandem engines, especially if in pairs.

Some of these engines are mentioned to show what large fly wheels are necessary to give the required belt speed to transmit the power, and to show the advantage of increasing the speed of Corliss engines in order to reduce the size of their fly wheels as well as other parts of the engines. For electric purposes dynamos can be constructed with revolving field magnets to take the place of the fly wheels, and these can run at 150 or more revolutions per minute, and it will certainly make an economical machine if driven by a Corliss engine direct. For these and many other reasons the author advocates increasing the speed of Corliss engines, and thinks that a

non-liberating valve gear is better suited to high speed, than anything that can be made with a liberating device.

In 1885 the author designed a non-detaching Corliss valve gear, with a governor on the engine shaft, and, in his opinion, it was the first time the governor of a Corliss engine was used that way. The engine was made by Mr. W. T. Garratt, and placed in the Mechanics' Fair in San Francisco, where it ran a competitive test with other engines in regard to steam consumption, and the judges awarded it the gold medal, the highest premium for the best and most economical steam engine.

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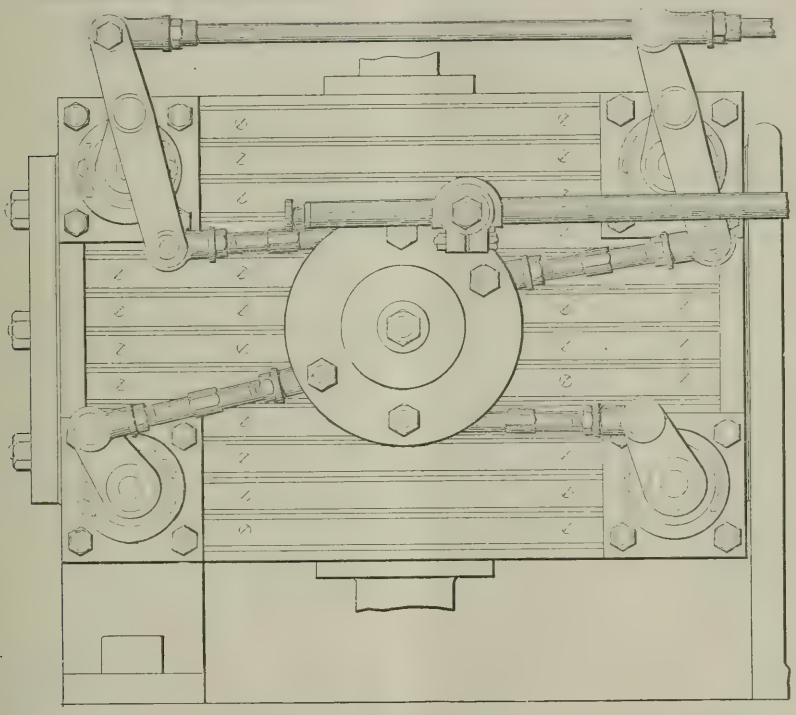


FIG. 3.

PITCHFORD-CORLISS VALVE GEAR.—ENLARGED VIEW.

This engine was constructed with a cam motion, in a manner similar to that shown in the drawings in Figures 3, 4 and 5. The motion to the rock plate on the side of the cylinder was imparted by the main eccentric in the ordinary way, with the exhaust valve connections the same as other Corliss engines; but on the arms of the

steam valve stem there was suspended a floating lever, at a point between its two ends. The lower end of this lever received motion from the rock plate, and the upper end received motion from the cam on the engine shaft. The cam was formed of two concentric semicircles of different diameters blending into each other, and in revolving in contact with rollers on levers connected by rods to the upper end of the aforesaid floating levers, a motion was imparted at the proper time for closing the steam valves.

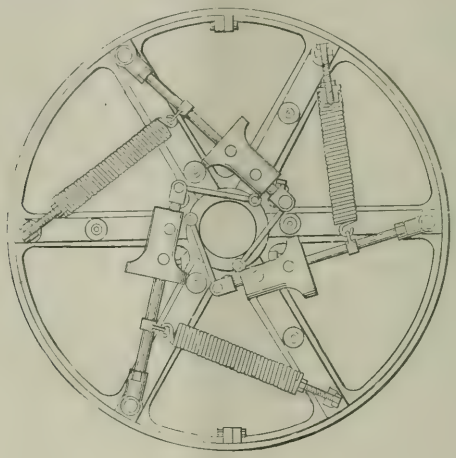


FIG. 4.

PITCHFORD–CORLISS VALVE GEARING.—GOVERNOR.

When the governor weights flew from the center by any acceleration of speed, the cam was advanced on the engine shaft, so that the steam was cut off earlier.

Another method employed by the author for imparting motion to the floating levers on the steam valve stem, is by means of bell cranks receiving motion from an eccentric, the angular position of which, is determined by the governor on the engine shaft, which advances this eccentric as the speed of the engine increases. The illustrations on page 186 will serve to explain this valve motion.

Sixteen of these engines have been made: thirteen by W. T. Garratt & Co., and three by the Phœnix Iron Works, in this City, and the author possesses good testimonials from the parties who are using them. One of these engines ran for over three years at a speed of 150 revolutions per minute, without needing one dollar's worth of repairs.

Francis Smith & Co., reporting upon one of these engines, say:

"The Pitchford Corliss Engine, 12″× 20″, at our electric light station in Watsonville is running 160 revolutions per minute. It runs a 650 light Thomson-Houston dynamo 1500 revolutions per minute. We have a water wheel in conjunction with the engine, and by means of a friction clutch coupling connecting our countershaft, we can run the dynamo with either steam or water power, at a moment's notice, and make the change while running, without causing the least flicker in the incandescent lights. We can also have engine and water wheel both running at the same time and then shut the water off the wheel without changing the speed of the engine, owing to the perfect regulation of the automatic governor. The engine is noiseless, and it takes very little fuel to run it, and in every way it gives good satisfaction."

This engine held its speed with 35 pounds variation in boiler pressure when working up to 40 horse power, when tested by Max Caspari, electrical engineer, and A. White, the company's superintendent at Watsonville.

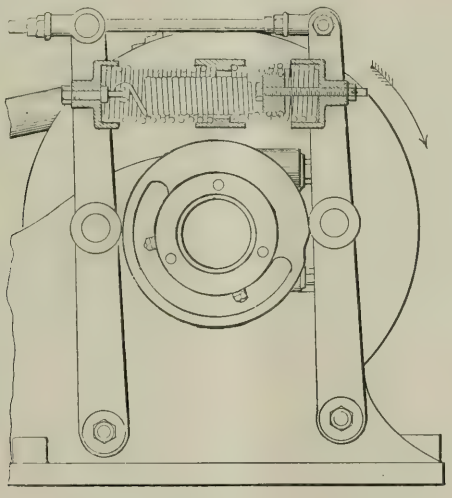


FIG. 5.

PITCHFORD–CORLISS VALVE GEARING.—ECCENTRIC.

One of these engines can be seen at Buckingham & Hecht's boot and shoe factory, in San Francisco; it is 12″× 24″, and runs 120 revolutions per minute; it has run 10 hours a day for over three and a half years, and uses very little more than three pounds of coal per horse power per hour.

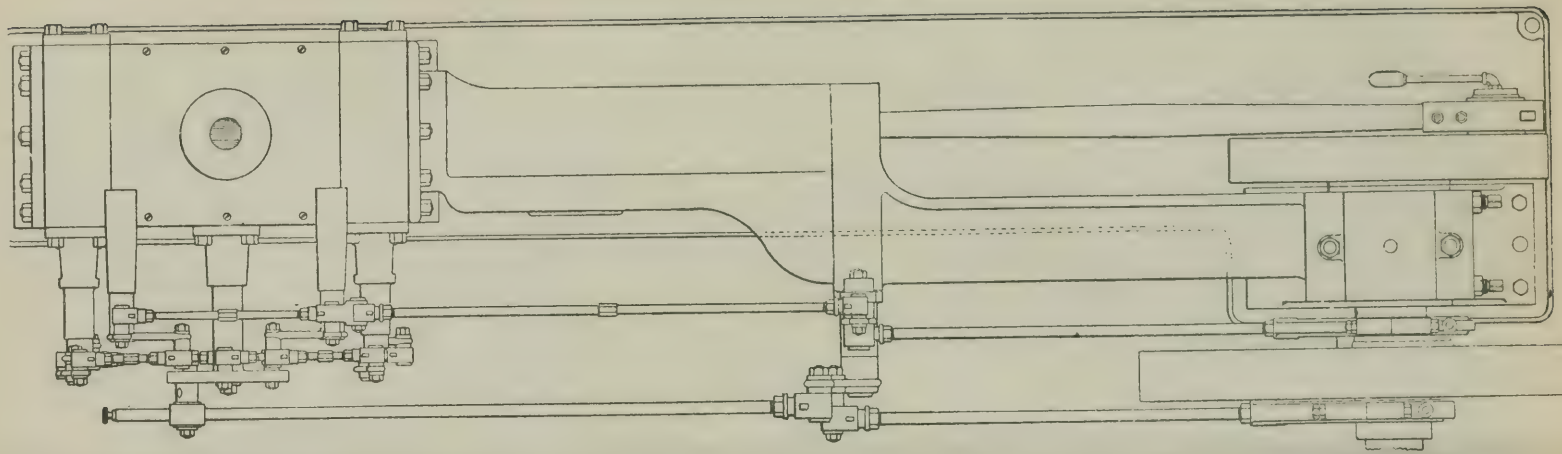


FIG. 6.

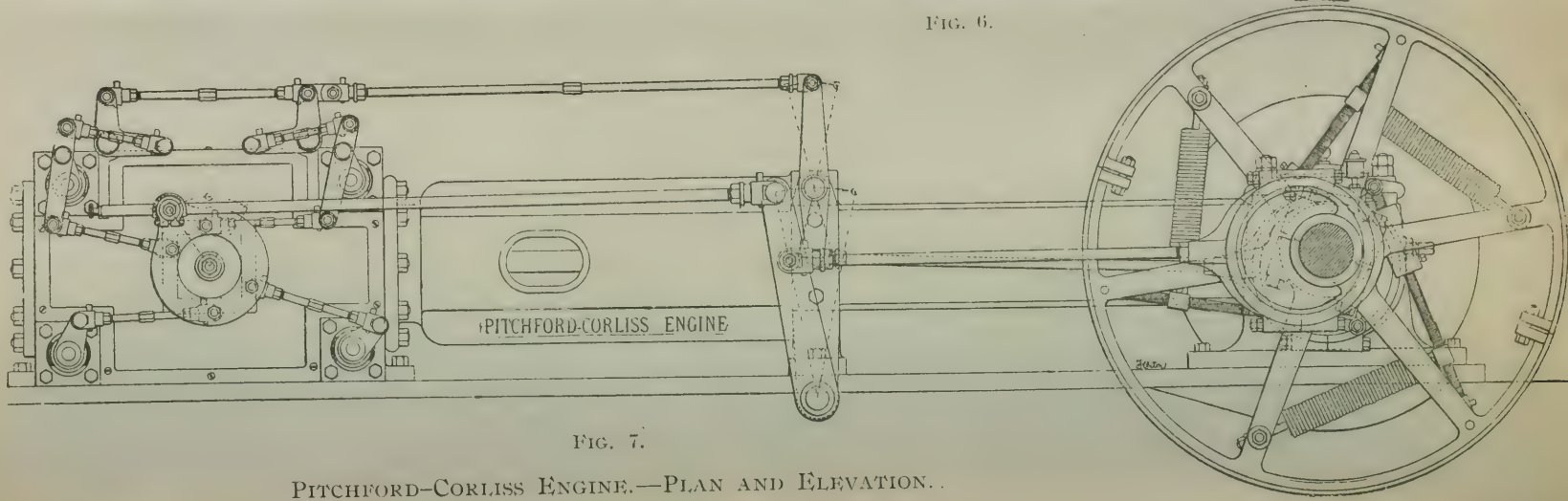


FIG. 7.

PITCHFORD-CORLISS ENGINE.—PLAN AND ELEVATION.

These three engines are referred to because it is found that quite a number of people in the engineering business are not aware that the Corliss engine can be run at a speed of 200 revolutions per minute.

A more detailed explanation of one form of this valve gear can be seen in the June number of *Power*, and a copy of a working drawing from which the 14″ × 24″ engine, now running the electric lights in Redwood City, was built, can be seen in the Magazine *Industry* for February, 1892.

EFFICIENCY OF HYDRAULIC PASSENGER ELEVATORS.

COMPARATIVE TEST OF THE "HYDRO-STEAM" AND PUMPING SYSTEMS.

By Prof. Horace B. Gale, Mem. Tech. Soc.

[Read August 5.]

Modern elevators for passenger service are usually operated by means of a piston driven by hydraulic pressure, a method which fulfils very well the requirements of ease of handling, combined with smooth and rapid motion of the car. The hydraulic piston carries at the outer end of its rod one or more grooved pulleys, or sheaves, around which the wire ropes supporting the elevator are passed. By taking a sufficient number of turns of the ropes alternately around these sheaves and other fixed sheaves, the speed of the elevator car can be made any desired number of times greater than that of the piston. There are two principal methods in use for obtaining the water pressure necessary for propelling the piston, namely, the pumping, or tank system, and the hydro-steam system.

By the former, which is the older system and the one at present in more common use, the water pressure is derived either from an open tank on the roof, or from a closed tank having the upper part filled with air under the required pressure. In cities, or other places where water is expensive, the water which has done its work is received in a waste tank in the basement, from which a steam pump returns it to the pressure-tank, the same water being used repeatedly. The choice between an open or closed pressure-tank depends upon circumstances. The closed tank has the advantage that it can be operated under as high pressure as may be desired, while the pressure from an open tank is limited by the height of the

building. On the other hand the open tank permits a somewhat more regular, and therefore more economical, action of the pump. As the system is generally arranged, the upper side of the hydraulic piston is always in communication with the pressure tank. When the controlling valve is adjusted so that the water under the piston can escape, the piston is driven down, and the elevator car is raised. To lower the car a passage is opened between the two ends of the hydraulic cylinder, thus equalizing the pressure on the two sides of the piston. The latter is then raised by the unbalanced weight of the car, the water flowing around from the upper to the lower end of the cylinder. As the weight of the car is usually more than is necessary to give the desired speed in lowering, a part of it is counterbalanced by an iron weight, which serves also to reduce the work done by the water in lifting the elevator.

In the hydro-steam system the water acts only on the upper side of the piston. The counterbalance consists of a column of water contained in a closed cylindrical vessel called a receiver, located at such a height above the hydraulic cylinder as will give sufficient pressure to balance the desired fraction of the weight of the car. The connection between the piston and elevator car is by means of wire ropes passing around multiplying sheaves, as in other hydraulic elevators. When it is desired to raise the elevator, steam from the boiler is admitted to the top of the receiver, and, pressing on the surface of the water, forces it down into the working cylinder, driving the piston before it. To lower the car, the steam is allowed to escape from the receiver, when the weight of the car lifts the piston, and the column of water resting upon it, the water being forced back into the receiver. By closing a valve in the water passage between the cylinder and receiver, the elevator is stopped and held at any desired point. It is evident that with this system of working no pumping machinery is required.

The successful operation of the hydro-steam system depends largely upon the perfect action of the water and steam valves. The construction of these was well described in a paper read before this Society in May of last year by Mr. R. Hinchliffe, and I will therefore omit any description of them here.

The water counterbalance presents some advantages over the forms previously used. By the use of a suitable proportion between the diameter of the receiver and that of the working cylinder, the height of the column resting on the piston is made to diminish as the elevator rises, and to increase as it is lowered, thus varying the

pressure of the counterbalance in such a way as to compensate perfectly for the weight of the ropes sustaining the car. Again, the ordinary counterbalance weight, by reason of its momentum, tends more or less to produce vibration of the car when it is suddenly stopped; but the water counterbalance, being cut off by the valve, can have no effect of this kind. In either of these two systems of operating elevators, the working cylinder may be either vertical or horizontal, according to convenience.

The question of the comparative efficiency of the two systems is reduced to the question, whether, under the conditions of elevator service, more work can be done upon a hydraulic piston by applying steam pressure directly to the surface of the water, or by using the same quantity of steam to pump water into a tank, from which the supply for working the elevator is drawn. It is evident that in the hydro-steam elevator the principal loss will be that due to the condensation of the steam on the surface of the water, and on the comparatively cold sides of the receiver. This loss is reduced as much as possible by clothing the receiver with nonconducting material, and by preventing the agitation of the surface of the water by the entering steam. It is to be remembered also that in this apparatus the steam is always brought in contact with the same body of water, which remains permanently at a temperature of about 212 degrees Fahrenheit.

In the pumping system, especially if a compound pump is used, the losses by condensation of steam will be smaller, but we have added losses due to leakage and friction in the pump and pipes. Moreover, under this system, all the water used has to be pumped against a pressure sufficient to raise the heaviest loads which the elevator has to carry, and just as much water, and consequently as much steam, is required to raise the elevator empty as to lift it with a full load of passengers. On the other hand, in a hydro-steam elevator, by applying a throttling governor, similar to the governor of a steam engine, to the steam supply pipe, the quantity of steam used on each trip of the elevator can be adjusted to correspond to the load carried, and a considerable saving made. By this method also the speed of the elevator is kept the same under all loads within the limit of its capacity. The attendant has only to open the steam valve wide, and as soon as the desired speed is attained the governor acts, and prevents a too rapid motion.

It appeared to the writer that the only reliable way of striking a balance between these opposing elements of economy, would be by

means of an accurate test of the two methods under the actual conditions of practice in passenger service. The tests here described were undertaken with that object.

The first test was made June 4, 1892, on the hydro-steam elevator in use in the St. Ann's Building in San Francisco. This elevator is of about the usual capacity of those in modern office buildings, being able to carry ten persons, and having an average speed of about 300 feet per minute. The whole travel of the elevator is about 60 feet, the motion of the hydraulic piston being multiplied three times. The cylinder is vertical, $12\frac{7}{16}$ inches in diameter; full stroke, 20 feet. The diameter of the piston rod is 2 inches, making the effective area of the working piston 118 square inches. The area of the steam receiver was, in this case, about 112 square inches, and the average height of the column of water constituting the counterbalance was 30.6 feet. The lower end of the working cylinder was in communication with the atmosphere. Steam was supplied to the receiver from a horizontal tubular boiler in the basement of the building, the exhaust steam passing through an open feed-water heater.

The test lasted from 10:45 A. M. to 4:55 P. M., during which time the elevator was run on its ordinary service, and the work done by the water on the working piston was determined by taking an indicator diagram from the hydraulic cylinder for every trip of the elevator. The feed-water pumped into the boiler during the same time was weighed in a barrel resting on platform scales. The boiler supplied steam only to the elevator, and a small feed pump. The exhaust from the feed pump was condensed in the weighing barrel, and deducted from the total water fed to the boiler, to obtain the weight of steam supplied to the elevator alone. The water level in the boiler, and the steam pressure, were the same at the beginning and end of the test.

Immediately before and after the test the boiler was allowed to stand several hours under full steam pressure with all valves closed, while the level of the water in the gage glass was noted, to make sure that there was no serious leakage of water or steam from the boiler. The scales used for weighing the water were tested immediately before the experiment by comparison with standard weights, and the spring of the Crosby Indicator used was tested two days afterward and found correct. The indicator was attached, by a ½-inch pipe, to the top of the working hydraulic cylinder, and stood about 12 inches above the piston at the top of its stroke. The cord was attached, through a reducing gear, to the piston rod. All the indi-

cator diagrams were carefully measured with the planimeter, and from them were deduced the mean pressures on the piston, due allowance being made for the average height of the column of water between the working piston and the indicator. After the test, diagrams were taken with the elevator running empty, in order to determine the work lost in friction, and the unbalanced weight of the car and ropes. The performance of this elevator in regard to speed and smoothness of motion is equal to that of the best hydraulic elevators in use. The following are the tabulated results of the test:

Duration of test	6 hours 10 minutes.
Number of trips made by elevator	256.
Total number of persons carried on up trips, including attendant	992.
Total travel of elevator one way	12,543 feet.
Average length of trip	49 feet.
Average speed (about)	300 feet per minute.
Average boiler pressure	81 pounds.
Ratio of travel of piston to length of indicator diagram	80 to 1.
Scale of indicator spring, pounds per inch	60.
Average pressure per square inch on working piston during up trips	48.6 pounds.
Average pressure due to water counterbalance	12.7 pounds.
Effective pressure, up trips	35.9 pounds.
Total travel of piston, one way	4,181 feet.
Number of foot-pounds of effective work done on up trips	17,711,550.
Total weight of steam supplied to elevator during test	2,057 pounds.
Work done in raising elevator per pound of steam	8,610 foot pounds.
Mean unbalanced weight of car and ropes	842 pounds.
Mean force required to overcome friction of sheaves and piston	185 pounds.
Mean load carried on up trips	385.2 pounds.
Maximum pressure on piston per square inch	90 pounds.
Deduct for counterbalance	12.7 pounds.
Maximum effective pressure	77.3 pounds.

The observations showed very well the variable character of the work done in ordinary elevator service. The number of passengers carried on different trips during the test varied from zero to ten. Sometimes the car would go up fully loaded, and come down empty, at other times the reverse. Usually passengers would be left at various floors on the way up, and taken in, similarly, on the way down. Sometimes a trip would be made only part way to the

top, the average trip being 49 feet, whereas the full travel is 60 feet. The effects of all these variations are plainly shown on the indicator diagrams, copies of some of which are appended. (See diagrams 1 to 6.) The fluctuations of pressure due to the sudden opening and closing of the valves are also apparent. It should be mentioned that as the elevator on which these tests were made was not provided with a steam governor, the full benefit of this variable work in saving steam could not be realized, most of the throttling under the small loads being done at the water-valve between the cylinder and receiver.

In order to compare the efficiency of this elevator with that of one operated by the pumping and tank system, it is necessary to know both the economical performance of a pump employed on this kind of service, and the ratio between the pressure against which the pump works, and the maximum effective pressure that may be realized in the hydraulic cylinder. The second test herein described was made July 2, 1892, with the object of ascertaining these facts.

It should be noted here that whereas on the hydro-steam system the efficiency of any number of elevators worked together is the same as that of a single elevator, the efficiency of the pumping system is greater the larger the number of elevators that are supplied by one pump. This is true, both because a large pump is more economical than a small one, and because when supplying a number of elevators the demand upon the pump is more uniform, and its action steadier.

The pump selected for this test was a Knowles compound duplex pump of the latest pattern, having high and low pressure pistons respectively 8 and 12 inches in diameter. The diameter of each of the water pistons was 7 inches, and the normal length of stroke 12 inches. The pump is located in the Redington Building, on Second Street, San Francisco, and supplies water to ten elevators,* which are used for various purposes, and operated on the open-tank system. The makers of this pump state in their catalogue that it is designed to work most economically under a steam pressure between 40 and 60 pounds. During the test the pressure actually realized in the high-pressure cylinder was kept between these limits, and was obtained by throttling from a boiler pressure of 80, thus insuring very dry steam. The pump was run at a nearly uniform speed throughout the test, the number of strokes per minute of each pis-

*Three traveling 72 feet each, four traveling 62 feet, and three with a travel of 8 or 9 feet each.

ton varying between 40 and 60. Before beginning it was examined and found to be in good condition, with packing not too tight for easy running, and from what has preceded it appears that it was well proportioned to its work, and run under as favorable conditions for economy as can often be found in this class of service.

The steam for the pump was furnished by a horizontal tubular boiler standing close beside it, the feed being supplied by a small single-acting pump with 1¼-inch plunger attached to the cross-head of the main pump. The displacement of the feed pump was only $\frac{8}{10}$ of one per cent. of that of the main pump, but as it worked against nearly double the pressure (80 pounds, instead of 45), in calculating the work done in pumping, twice the actual displacement of the small plunger was allowed. During the trial the boiler supplied steam only to the main pump. The amount of water fed to the boiler was weighed in the same manner as in the first test, the same scales being used in both cases. The steam pressure and water level in the boiler were the same at the beginning and end of the experiment. The same test as before was also applied to ascertain that there was no leakage of water or steam from the boiler. The water gage showed the same level after standing under pressure over night.

The number of strokes made by the pump during the test was recorded by an automatic counter, and the cushion valves were adjusted at intervals so as to make the length of each stroke conform as exactly as possible to a 12-inch scale. The pressure against which the pump worked was determined by an accurate Crosby test gage connected to the forcing pipe at a point directly over the suction reservoir, the height of the gage above the mean level of the water in the reservoir being carefully measured and due allowance made therefor. The gage had been tested immediately before using it, and found correct. No allowance was made for slip in the pump, it being credited with the full apparent displacement of the two pistons.

While the pump test was in progress, observations were made upon one of the elevators supplied from the pressure tank, one of the Otis standard vertical-cylinder pattern, to ascertain the ratio between the pressure against which the pump worked, and the maximum effective pressure that could be realized on the hydraulic piston. The same Crosby indicator and reducing gear were used in this work as had been previously applied to the cylinder of the hydro-steam elevator, except that as the water acts on both sides of

the piston in the Otis construction, a pair of indicators were used, and cards taken simultaneously at both the upper and lower ends of the cylinder. This elevator was used mostly for freight purposes, but the construction of the cylinder and valves is identical with that used for passenger elevators. The mean speed of the car, empty and under light loads, was about 175 feet per minute. It was found that, owing to the throttling action of the valves and passages, the effective pressure fell off rapidly as the speed of the elevator increased.

In order to get the maximum effective pressure that could be realized under full load and at low speed, the car of the elevator was loaded with bales of straw weighing 150 pounds each. With a load of seven bales the car refused to rise. With six bales it went up slowly, rising through its full travel of 72 feet in 51 seconds, or at the rate of about 85 feet per minute. This was therefore considered to be the full load for the elevator. The effective pressure on the piston, corresponding to this load and speed, was 36.2 pounds per square inch, while the pressure against the pump was 45.5 pounds, making the ratio of pump pressure to maximum effective pressure on elevator piston 1.25. As elevators of this type use the same quantity of water and steam at all loads, it was unnecessary in this case to take diagrams for every trip; but a number were taken under different conditions, and the friction and unbalanced weight of the car determined as before. (See diagrams 7 and 8.) In the diagrams taken from the top end of the cylinder the atmospheric line *A* has been raised, in the figure, above that on the diagrams from the lower end, by an amount corresponding to the difference in the level of the two indicators. The dotted lines show the static pressures at the same points. The distance between the dotted lines and the actual lines of the diagrams corresponds to the loss of pressure due to the throttling action of the valves and pipes. The results of the observations during this test are given in the following table :

Duration of test	7 hours.
Average boiler pressure	80 pounds.
Diameter of pump pistons	7 inches.
Diameter of pump rods	1¾ inches.
Diameter of feed pump plunger	1¼ inches.
Effective area of pump pistons, corrected for rods and feed-pump plunger	37.9 square inches.
Mean length of stroke, each pump	12 inches.
Number of double strokes, one pump, by counter	9,987.
Total travel of both pump pistons	39,948 feet.

Mean pressure on force pipe, by gage	41.2 pounds.
Mean height of gage above water level in supply tank	9 feet 11¼ inches.
Total effective pressure against pump	45.5 pounds.
Total work done in pumping	68,888,329 foot-pounds
Weight of water fed to boiler	2,965 pounds.
Foot pounds of work in pumping, per pound of steam	23,234.
Diameter of hydraulic cylinder of elevator	13 5/8 inches.
Full stroke of hydraulic piston	24 feet.
Diameter of hydraulic piston rods (two in number) each	1¼ inches.
Ratio of multiplying sheaves	3 to 1.
Scale of indicator springs, pounds per inch	30.
Height of water column between upper and lower indicators	25 feet 9 inches.
Unbalanced weight of car and ropes	640 pounds.
Mean force required to overcome friction of sheaves and piston	154 pounds.
Maximum load carried, according to indicator diagrams	895 pounds.
Maximum effective pressure per square inch on hydraulic piston	36.2 pounds.
Ratio of pump pressure to effective pressure on working piston	1.25

The above tabulated results afford us the means of comparing the efficiencies of the two systems of operating elevators. From the first table, we find that the whole quantity of steam supplied to the hydro-steam elevator during its test was 2,057 pounds, and that the total travel of the working piston in lifting the car during the same time was 4,181 feet. The effective area of the piston being 118 square inches, the volume of water that would be required to do this work under a pumping system would be $4,181 \times 118 \div 144$, or 3,426 cubic feet. The maximum effective pressure realized on the piston of the hydro-steam elevator was 77.3 pounds, and calling the ratio of pump pressure to effective pressure on the piston 1.25, the pump would have to force this volume of water against a pressure of 77.3×1.25, or 96.6 pounds per square inch. The quantity of work represented by these figures is 47,658,383 foot-pounds, which, divided by 2,057, gives us the number of foot-pounds per pound of steam as 23,169. This is what a pump must do to equal the performance of the hydro-steam elevator under the conditions of this experiment. The actual performance of the pump tested, in foot-pounds per pound of steam, was, as shown by the table, 23,234. The difference being less than $\frac{3}{10}$ of 1 per cent., the writer concludes

that the efficiency of the hydro-steam elevator as at present in use for passenger service is about equal to that which can be obtained with tank elevators operated by a good compound pump. Compared with the performance of the non-compound pumps often used for elevator work, the hydro-steam system would therefore have a considerable advantage; and a further advantage may be gained, doubtless, by the use of the throttling governor in the steam pipe.

The average number of pounds of steam per trip used by the hydro-steam elevator in this test was about eight, which agrees well with the results obtained in the experiments of Mr. Hinchliffe. The travel of this elevator being 60 feet, and its capacity 10 persons, we are afforded a rough means of estimating the boiler power required for passenger elevators on this system.

It is interesting to notice that the quantity of steam actually used per trip by the elevator in these experiments was about three times what would have been required to fill the receiver if there had been no condensation. A rough calculation also shows that the heat required to raise the temperature of the iron sides of the receiver from 212 degrees to the temperature of the entering steam is sufficient to account for the greater part of this condensation. It is therefore probable that a comparatively small proportion of the steam is condensed on the surface of the water, the depth affected being very small.

It is evident that if a means were devised to prevent the lowering of the pressure, and consequent cooling of the inside of the receiver during the exhaust, the heat required to raise the temperature again to that of the admission steam might be largely saved. To accomplish this, the writer has suggested that the top of the receiver, instead of being opened to the atmosphere when the elevator is lowered, be put in communication with the bottom of the working cylinder, thus equalizing the pressure above and below the piston. To raise the car, the steam would then be exhausted from beneath the working piston, and at the same time admitted to the top of the receiver. This plan would require only one additional valve, and it is thought would prevent a large part of the condensation due to the alternate heating and cooling of the receiver. On some elevators now under construction this principle is to be adopted, and the writer hopes soon to be able to present results with these, showing a considerable advance in economy.

A further matter of interest brought out by this test is the fact that if the work done by the elevator on the piston on the down

trips be subtracted from the work done by the piston on the up trips the mean effective pressure is reduced to 10.122 pounds per square inch, and the net effective work, up and down, is only 2,420 foot-pounds per pound of steam, instead of 8,610 foot-pounds. This indicates that the modern passenger elevator is, to say the least, an exceedingly uneconomical form of heat engine. The inference is that if the steam could be worked in such a way that the down traffic could assist in lifting the up traffic, a very large saving would be effected. It is a pleasure to state that Mr. Hall is now well on the way to the solution of this problem, and if he is successful, we may expect soon to see a three-fold increase in the efficiency of the hydro-steam elevator.

REGULAR MEETING, AUGUST 5th, 1892.

PROCEEDINGS.

MINUTES.

The meeting was called to order by the President, Mr. John Richards.

The minutes of the last regular meeting were read and approved.

The following new members, having been balloted for, were declared elected:

Edward Lownes, Civil Engineer.....Riverside, Cal.
W. H. Sanders, Civil and Hydraulic Engineer.....Pomona, Cal.
Wm. Praun, Architect.....San Francisco, Cal.

The following names were proposed for membership, and referred to the Executive Committee:

Mr. H. E. C. Feusier, of the U. S. Geological Survey; proposed by Willard D. Johnson, Otto von Geldern and Hubert Vischer.

William A. Doble, Mechanical Engineer, San Francisco; proposed by John Richards, E. J. Molera and H. C. Behr.

Two communications were read, one from the President to the manager of the Byron Hot Springs, and the other from Mr. C. R. Mason, Manager, to the Society, relative to a proposed visit of the Technical Society to that well-known resort. Upon motion this matter was referred to the Executive Committee for subsequent action.

A letter was read from Messrs. L. C. Russell and E. A. Rix

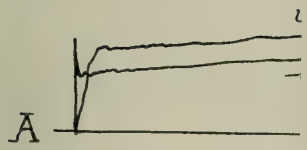
members of a committee to draw suitable resolutions of respect in memory of the late member, Andrew J. Fraser. The communication was filed, and the committee granted further time.

Mr. John B. Pitchford, Mechanical Engineer, then read a paper entitled "Corliss Engines," the discussion of which was postponed until a subsequent meeting.

The second paper read was on the "Efficiency of Hydraulic Passenger Elevators," a very comprehensive report of a comparative test of the hydro-steam and the pumping systems, by Prof. Horace B. Gale. The discussion of this paper was also postponed until the next regular meeting of the Society.

The third paper of the evening was read by Lieutenant Jno. P. Finley, U. S. A., Chief of the Meteorological Service on the Pacific Coast, and referred to the general Circulation of the Atmosphere, being a discussion of the paper read at the June meeting by Mr. Marsden Manson. After the reading of the paper Mr. Manson announced that he would submit a part of the discusssion in reply, in time to be published with the paper read by Lieut. Finley.

Adjourned. OTTO VON GELDERN, *Sec'y.*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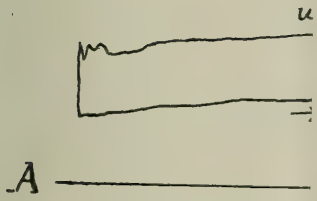
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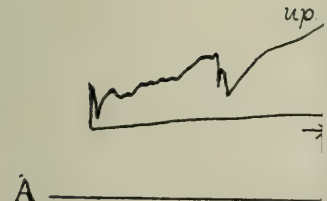
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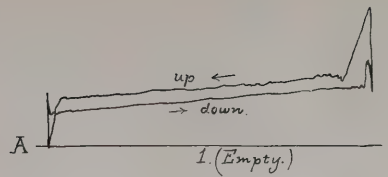

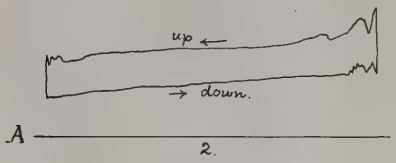

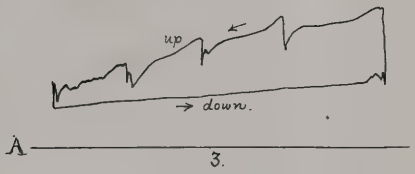

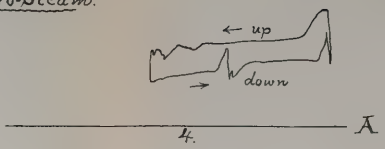

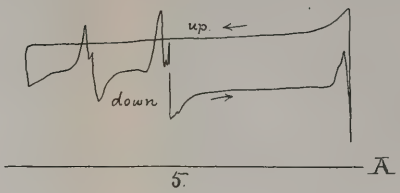

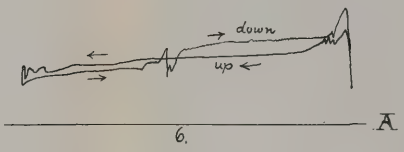

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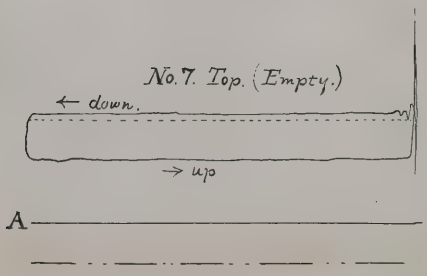

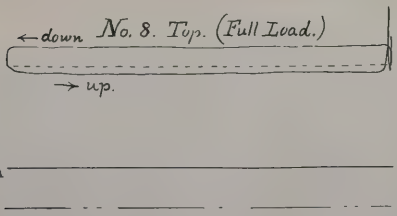

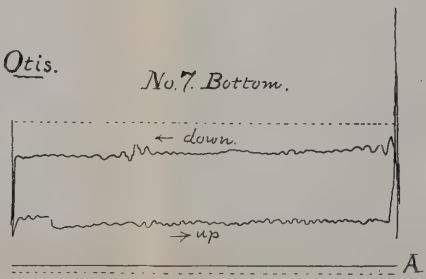

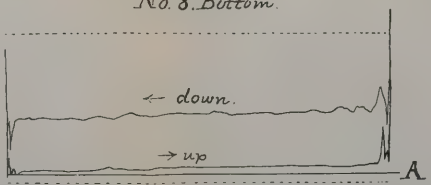

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME IX. No. 8.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

REMARKS ON THE GENERAL CIRCULATION OF THE ATMOSPHERE.

BY LIEUT. JNO. P. FINLEY, U. S. ARMY.

[Read August 5, 1892.]

At a previous meeting of the Technical Society (June 3rd last) I was kindly invited to make a few remarks upon the principal paper of the evening, "The Circulation of the Atmosphere of Planets," read by the author, Mr. Marsden Manson, a member of the Society.

This paper is worthy of very careful study, for the subject matter is comprehensive and fundamental in the branch of science to which it relates. Moreover, the discussion presents original and very interesting conceptions, and the manner of treatment shows great care in preparation. In my first comments I admitted the effect of solar radiation in the production of atmospheric motion. I placed the axial rotation of the earth in this category as also giving rise to such motion, but did not hesitate to consider its effect, in a measure, secondary to that of solar energy.

While Mr. Manson endeavors to explain the circulation of the atmospheres of all planets, yet his chief purpose is to show that the

general motions of the atmosphere of the earth are the result of solar radiation exclusively. He assumes that the axial rotation of the earth is not a determining factor in the general circulation of the atmosphere. In support of this assumption he presents two illustrations, in one of which the sphere is represented as having no axial rotation, but with the source of light and heat revolving from west to east about the sphere. In the other case, the sphere is set in motion but the source of light and heat remains stationary. In both instances Mr. Manson obtains practically the same results in the development of general atmospheric motions from west to east.

Of course with the sphere in rotation the varying tangential velocity, with change in latitude, will give rise to apparent modifications in the general flow of the atmosphere from west to east near the surface of the earth. Thus at the Equator, and thence north and south to the Tropics of Cancer and Capricorn, the tangential velocity is much greater than the motion of the atmosphere (both moving from west to east), so that the atmosphere has a relative motion toward the west, and easterly winds are observed, which are commonly called the trade winds.

There is an evident mistake of the draughtsman in diagram No. 3 of Mr. Manson's paper, illustrating the wind systems of the globe, in which the climatic circles of Cancer and Capricorn are reversed. Fortunately this error does not militate against the merit of the author's argument. North and south of the Tropics the general motion of the atmosphere under the influence of solar radiation would predominate and westerly winds prevail. From this position in the discussion Mr. Manson feels justified in stating that "the question of whether the atmosphere would revolve with the planet, irrespective of the effect of solar energy, is not considered." In taking this position Mr. Manson must neglect any influence which may result from the resistance of the surface of the sphere to the motion of a viscous fluid like the atmosphere. It is generally conceded by leading meteorologists that this resistance has an appreciable effect on the general circulation of the earth's atmosphere.

Professor Abbe says, in his recent work on Deductive Methods in Storm and Weather Predictions, that in studying the general disturbances of the earth's atmosphere we need to take into account the following primary sources of energy: The rotation of the earth on its axis; the attraction of gravitation of the earth, and the heat received by radiation from the sun.

We also need to consider the following methods by which energy is lost, transferred, or transformed: The absorption of

solar radiation by the earth and air. Radiation and convection of heat from the clouds to the atmosphere. Radiation of heat from the atmosphere into space. The absorption of heat rendered latent in the evaporation of moisture at the surface of the ground, and of the clouds, and within foggy air. Resistance of the earth's surface to the motion of the air, additional to those resistances that a smooth surface would offer to the steady motion of a viscous fluid. The viscous resistance of the air to its own internal or differential motion. The resistance or conversion into thermal or other forms of potential energy, of the kinetic energy annulled when two currents of air interfere with each other. The evolution of latent heat by the cooling and condensation of aqueous vapor.

Other influences of less importance may be mentioned as follows: Influence of lunar heat. Influence of the heat of the stars. Influence of the interior heat of the earth. Influence of the heat of shooting stars. Variations of solar radiation due to changes on the solar surface. Influence of atmospheric electricity. The tidal influence of sun and moon. Magnetic influences.

If all of these influences and sources of energy are at work upon our atmosphere it is not difficult to realize that the problems involved as to the causes of motions, both general and local, are very complex. And yet we do not hesitate to say that the principal source of energy is solar radiation. To prove that it is the only source of energy in the development of the general circulation of the atmosphere is not easy to accomplish, in the face of the investigations of leading meteorologists who view the matter differently in the most recent publications.

It is, of course, a fact beyond dispute that we do not yet appreciate, or intelligently comprehend, the extent and variety of the effects of solar energy upon both animate and inanimate nature. But Mr. Manson asserts that in discussing the great problem of the general circulation of the atmosphere it is not important to consider any effects which result from a modification of solar radiation by conditions on the surface of the earth. He says that "the variations are many, and produced by various causes, but all are foreign to a discussion of the prime problem, and will not be considered." Yet in explaining the calms of Cancer and Capricorn, "the apparent reversal of the west winds with the easterly trades of the Torrid Zone" and the equatorial calm belt, Mr. Manson finds it absolutely necessary to consider the formation of clouds, their extent and depth, and their influence in modifying the direct effects of solar radiation.

Moreover, he considers the development and progressive motion of cyclonic disturbances, and the rain areas connected with them, in explaining atmospheric circulation within the Torrid Zone. Now these are "variations" resulting from the contrasted land and water features of the earth's surface, through the influence of the dynamic forces of evaporation and condensation.

In order to fully realize Mr. Manson's conceptions, as to the entire adequacy of solar radiation in developing and maintaining the general circulation of the atmosphere, it seems necessary to consider the globe as a perfectly uniform sphere of some unknown material. An ideal globe suited to the requirements of the theory. Such a globe must have a uniform velocity of axial rotation (west to east) from the Equator to the poles, or else no rotation at all. In one case the source of heat must remain stationary, and in the other it must revolve from east to west. The effect of sufficient heat upon the atmosphere of such a globe, under such conditions, would result in producing a general and uniform circulation from west to east. We cannot deny that solar radiation is entirely adequate for this result under the circumstances, or even to be the sole cause of the general motions of the earth's atmosphere. The power and energy is probably there, in the composition of the sun, but the question is, does a solution of the problem require this force, and not only that, but does it operate to the exclusion of every other adequate source of energy?

Of course this discussion is mainly theoretical, the success obtained being largely dependent upon the reasonableness of the propositions advanced and defended. In view of the fact that so much depends upon limiting the discussion to the so-called "general circulation of the atmosphere," it would have been well to define quite explicitly what is to be understood by such a circulation. If about two thirds of the atmosphere possesses a tendency, and to a large degree does actually move from the west, while the remaining portion moves in a contrary direction, it can hardly be questioned that the latter is a part of the so-called general circulation of the atmosphere. If we find that the axial rotation of the earth, or the formation of cloud belts dependent upon the condition of the surface of the earth, control about one third of our atmospheric circulation, then we are hardly justified in assigning some other cause, as solar radiation.

Right here lies the critical part of this discussion. The movement of about two thirds of our atmosphere conforms very nicely to

the solar radiation theory, but the remaining third inclines to be contrary. At this juncture Mr. Manson very skillfully introduces the wonderful atmospheric effects produced by the explosion of the volcanic island of Krakatoa, in the Straits of Sunda, in August, 1883, and finds that the dust from this explosion was carried by the winds entirely around the earth within the Torrid Zone, from east to west. North of the calms of Capricorn, and south of the calms of Cancer, the dust stream moved about the earth from west to east, or directly contrary to the course pursued within the Torrid Zone. He takes the average velocity of this dust stream (about eighty miles per hour, within the Torrid Zone) ascertained after the laborious investigations of a special committee of the Royal Society of London, and shows that it is not an actual velocity from east to west, as apparently claimed, but only relative, owing to the lag from the excess of the tangential velocity of the earth over that of the general circulation of the atmosphere from west to east.

This peculiar westerly movement of the air currents and dust stream attracted more than ordinary attention from the committee, and caused the particular member having charge of the meteorological work to resort to considerable mathematical analysis in an effort to reach a logical conclusion as to the determining causes.

Mr. Manson sees, in this peculiar westerly movement, and especially in the average velocity of the dust stream, an indirect verification of his solar radiation theory of the general circulation of the atmosphere. He has found that this westerly lag, of about eighty miles per hour in the Torrid Zone, is just what the difference ought to be between the tangential velocity of the earth, and the velocity of the atmosphere under solar energy in that zone. But there is no question as to this difference or its cause. It is generally accepted within the Torrid Zone, because the earth moves faster than the atmosphere above it, consequently there must be a relative motion of the latter toward the west. I do not find from an examination of the very elaborate report of the committee of the Royal Society that they deny the existence of this relative westerly motion. There can be no question about the actual westerly movement of the stream of volcanic dust. The observations are numerous and accurate, the self-registering barographs recorded the pulsations of the atmospheric waves, and the laws of atmospheric circulation were not contravened.

The committee show the characteristic conservatism of high scientific training and methods in saying that, "whether the material

spread by the action of any other laws than those which usually regulate the motion of the air in which it floated, and at what time it ceased to move from east to west it is difficult to say, but the facts negatively favor the view that by the time it reached latitude 30 degrees it no longer possessed that due east to west direction, by which, at first, its general motion within the tropics were so markedly characterized."

And furthermore in the statement: "There is, indeed, a remarkable absence of any succession of appearances from east to west, beyond latitude 30 degrees north, and a general impression conveyed by the facts, that while the material was crossing this limit it was simply spreading north and south, and afterwards turned around so as to move, if anything, from southwest to northeast."

After quoting these remarks from the report of the committee, Mr. Manson says: "It will be observed that in this quotation very important facts are recorded, but that a remarkable interpretation of them is rendered in referring to the apparent motion of the dust cloud, at from seventy to eighty-three miles per hour from east to west, as an actual velocity in that direction, when, in reality, at no other latitude could this dust cloud have been borne in the opposite direction at the high rate of speed noted above."

It seems to me that Mr. Manson has mistaken the meaning of the words of the committee. They appear to properly record the dust stream as an actual movement westward in the Torrid Zones of clouds of volcanic ashes, and in the Temperate Zones a translation of the dust particles from west to east. That the dust streams had an actual progressive movement in these directions is a matter of authentic observation. In recording the facts there was no necessity for stating that the observers saw what was really an illusion because of their relation to the axial rotation of the earth, and to the independent motion of the atmosphere.

Then again, it was the purpose of the committee to record the facts and all of the accessible information with as little speculation about the data as would justify and provide for an unprejudiced and complete presentation of the investigation. Where theories are promulgated in the report the authors are made responsible for the views presented, and readers can form their own conclusions.

Concerning this east to west motion in the Torrid Zones the following extracts are made from the committee's report on pages 429, 435, 436 and 437. Speaking of the exceptions to the general movement

of the dust streams from east to west the report states: "The fact that these exceptional transmissions took place only to a limited extent, however, as well as the much greater velocity and mass of the main stream which made its way around the Equator, shows that while part of the ejecta was, as it were, entrapped by the ordinary wind systems, which prevailed at lower elevations and up to the level of the highest clouds, a large quantity of the material was probably projected to a level at which we have no means of ascertaining by the aid of clouds what are the motions of the air, since aqueous vapor does not exist in sufficient quantity to form them, and at which the prevailing motion is apparently a powerful current from the east, right around the Equator. All the leading facts regarding the earlier distribution of the optical phenomena tally with such a hypothesis. Also there does not seem to be any *a priori* objection to the existence of such a current, unless the phenomena demanded its presence in all parts of the world, which would involve a violation of the law of continuity."

If we desire to know which of the following five possible states is dominant in the upper regions of the atmosphere over the Equator viz:

(1) A motion from east to west.
(2) A motion from west to east.
(3) A motion from north to south.
(4) A motion from south to north.
(5) No motion at all.

"We can arrive at some preliminary notion from theory alone, for since the Equator is approximately an axis of thermal as well as rational symmetry, any motion of the air towards or from it, due to either, or both, solar heat and terrestrial rotation, should tend to occur symmetrically (viz, in opposite directions and equivalently) on each side of it. Meridional components should therefore vanish on the Equator, and have only small values in its neighborhood. East or west components, on the other hand, might have considerable but nearly equal halves on each side of it."

"While the meridional components of the trade winds are obliterated by their quasi-junction near the region of the doldrums or thermal equator, there is nothing to counteract their east to west components, and since, by the conditions of continuity, we must assume that they rise either as a common convection current, or else through an upward inflection of their stream-lines by a medial wedge of doldrums, the air up to a considerable elevation over the Equator should retain this combined east to west motion unchecked."

"If this east to west motion were once established in the upper atmosphere near the Equator, the air would tend to continue to move in that direction, owing to the fact that, apart from any decided poleward motion due to overflow, which we have shown cannot occur except at some distance from the Equator, the inertia curve in which the air would tend to move would in this case coincide with its initial direction."

"Regarding the question of the probable velocity of this east to west current over the equator, we know hardly anything beyond the evidence afforded by the present smoke stream."

"Observations of cirrus clouds in higher latitudes, certainly show velocities considerably exceeding eighty miles an hour, but these are in connection with large depressions near the poles and are not constant. The velocity in the present case could certainly not be attributed in any sensible degree to the westward lag of material ejected from the earth's surface, since even at a height of 120,000 feet, such lag would, at the most, amount to only six miles an hour, assuming that none of it was lost by friction during ascent. That the velocity might however be considerable at a high elevation near the Equator, in spite of a small gradient, is plain both from what was said about the general equations for the gradient, as well as from the complete equation for barometric gradient in terms of the velocity."

"We may therefore conclude that both theory and observation rather favor than otherwise the existence of a rapid and constant current from east to west for some degrees on each side of the Equator in the loftiest regions of the atmosphere, such as is demanded, if not shown to exist, by the succession of optical appearances after the August eruption of Krakatoa in 1883 traced in this report."

The committee acknowledge the combined effect of solar energy and terrestrial rotation in the production of general motions in the atmosphere. They do not, however, place special stress upon the influence of solar radiation or deny that it is the predominating source of energy. In the absence of absolute proof that solar radiation is the adequate and actual cause of the general motions of the atmosphere, it must be said that Mr. Manson has discovered a very interesting coincidence by his application of the "problem of the couriers" to the question of atmospheric circulation in the Torrid Zones. The western lag of 83.4 miles per hour, corresponds very closely to the estimated average velocity of the dust streams from Krakatoa from east to west.

According to the solar radiation theory of Mr. Manson, this velocity is simply a relative motion toward the west, due to the difference between the tangential velocity of the earth at the Equator and the easterly motion of the atmosphere under the effect of solar energy. In other words the so-called actual easterly movement of the atmosphere in the Torrid Zones is 954 miles per hour. Yet, according to the solar theory this relatively westerly motion is really a part of the grand westerly movement of the whole atmosphere. Therefore in conformity with the proposition of Mr. Manson, the actual velocity of the air in the Torrid Zones, from west to east, is really the tangential velocity of 900 to 1037.4 miles per hour. Moreover, if solar radiation is the sole actuating cause, the velocity of circulation ought to be very nearly uniform throughout the Temperate and Torrid Zones, whereas Mr. Manson makes a difference of 400 miles per hour between the Equator and the Tropics of Capricorn and Cancer. This difference is really the difference in tangential velocity with latitude, and the effect of solar radiation must be the equivalent of terrestrial rotation. The question arises, which is which, and what are really the independent effects of the two forces upon the atmosphere? It would appear that the varying angle of the sun's rays is not instrumental in changing the velocity of circulation with latitude, for Mr. Manson declares on this point as follows:

"By reason of the obliquity of solar rays, in latitude plus or minus 50 degrees, nearly twice as thick a stratum of air must be passed through at the Equator; hence a larger proportionate amount of heat is taken up, and proportionately a greater acceleration is acquired by the atmosphere of those latitudes."

Again, if solar heat is the exclusive source of energy in producing the general motions of the atmosphere, what are the conditions of circulation within the Arctic and Antarctic circles during the period of total darkness prevailing there each year?

In making the solar theory account for the calm belts at the tropics and over the Equator, resort must be had to the mechanical effect of masses of air moving with different velocities, not as the direct result of solar radiation, but of terrestrial rotation.

The conditions of atmospheric circulation which must obtain under the solar heat theory of Mr. Manson, are certainly developed with greater simplicity than the complicated methods involved in the elaborate hydro-dynamical theories of Ferrell and Sprung.

As to the circulation of the atmosphere of other planets than the earth, in the solar system, it seems very reasonable to assume that they are brought under the influence of solar radiation, with effects dependent upon distance from the sun, axial rotation, inclination of the axis of rotation, and density and composition.

In this connection Mr. Manson has presented some very interesting suggestions and propounded an apparently satisfactory theory for the circulation of the atmosphere of Jupiter. In view of Mr. Manson's interpretation of the cause of the rotating spots on Jupiter it seems somewhat strange that Mr. A. Stanley Williams, F. R A. S. author of *Zenographical Fragments*, in which these spots were first classified and discussed. should not have attempted to connect them in some way with the atmosphere of that planet. As discussed by Mr. Manson, their periods of revolution disclose some remarkable results in connection with the supposed general motions of the atmosphere of Jupiter under the influence of solar radiation. But these problems concerning other planets than the earth are more properly astronomical than meteorological in character.

Aside from any difference of opinion which must of course prevail in a theoretical discussion of this character, and especially in view of the subject matter treated, it must be said that the careful preparation, comprehensive investigation, originality and strength of argument, displayed by Mr. Manson in his paper on the Circulation of the Atmosphere of Planets, gives high standing to his work. It is certainly a valuable contribution to meteorology and may likewise prove to be for astronomy. I trust that the paper will receive the attention which it justly merits.

SKETCH MAP OF MOUNT ST. ELIAS REGION, ALASKA

By

Mark B. Kerr.

Western part from maps by H.W. Seton-Karr and W.H. Topham.

Coast line from U.S. Coast Survey.

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HEIGHT AND POSITION OF MOUNT ST. ELIAS.

By Mark Brickell Kerr,

Member Tech. Soc., National Geographic Society, and A. I. M. E.

[Topographer of the Expedition of 1890.]

DISCUSSION OF RESULTS.

[Read September 2d, 1892.]

A little over one hundred and fifty years ago Mt. St. Elias was discovered and named by Bering, the great voyager and explorer. Since then many navigators have observed the peak, and calculated an approximate height and position, with varying results. Many experienced mountaineers have endeavored to ascend and occupy the summit, but the storm king gathered his forces and rushed down in anger upon such daring invasions, and in a short time the huge uplifted giant was again left alone, unconquered and uncrowned.

Clouds and mist envelop the peak almost constantly, but occasionally the veil is raised, and the awed spectator is allowed a glimpse of its hidden beauty, between the passing and repassing of bright halos and skurrying, changing snowy banners. Will it be possible to measure the correct height without again attempting to ascend it is asked by the student in geography? A better approximation can of course be obtained. But to set at rest the discrepancies raised by earlier measurements, great care must be used to eliminate errors that are bound to creep in, where refraction and kindred elements are such unknown quantities, especially uncertain and serious in a trigonometric survey.

The writer, as topographer of the expedition of 1890, has collected considerable data, and in this paper will present technical points, touched upon only lightly in articles hertofore written. These thoughts should prove of much interest at this time, for the uncertainty existing in measurements made by former explorers has influenced the U. S. Coast and Geodetic Survey to fit out another expedition, which will soon return from this region. Messrs. McGrath and Turner, who so ably conducted a similar expedition up the Yukon River to determine astronomic points on the 141st meridian for future boundary reference, have been placed in charge. They are completely equipped with instruments needed for a

detailed survey, and will obtain many sets of observations more accurate and satisfactory than the hasty, and necessary preliminary, reconnoissances of the past few years. They will probably redetermine the geographic position of the station at Port Mulgrave, from which point the observations of 1874 were taken, and, if the weather permits, will sight St. Elias and other points from as many different stations as possible, thus endeavoring to eliminate errors which a lack of reciprocal angles is likely to cause.

This expedition will also make a more detailed topographic map of the coast line, establishing points of extreme accuracy by trigonometric survey. Upon this chart, data for the south-east boundary between Alaska and British Northwest Territory, will be laid down. It is hoped that the weather will remain clear enough for them to obtain a number of observations upon the principal peaks ; for without a check upon the work, the great distances between which observations are taken must lessen the value to be attached to the result, as it will probably be impossible to allow the time needed to ascend and occupy the principal peaks, and thus close the triangles.

Mt. St. Elias, lying so close to the intersection of the 141st meridian, with the theoretic line running northerly along the supposed continuous mountain crest from Portland Channel to the intersection with said meridian, is therefore not only an interesting but a very important factor in such a determination of boundaries. According to the terms of the treaty, between Great Britain, Russia and the United States, the boundary, after leaving Portland Channel, "should follow the windings of the mountain range, parallel to the "coast, until the 141st meridian is reached, and from thence north-"ward along this meridian to the Arctic Ocean. Should the moun-"tains be found more than ten marine leagues from the coast, then "the limits of the boundary shall be formed by a line parallel "to the windings of the coast, which shall never exceed the distance "of ten marine leagues therefrom." The distance between Mt. St. Elias and the nearest point of the coast (near Icy Bay) is about 33 statute miles, so that Mt. St. Elias is very near being the point where this theoretic boundary from the south meets the 141st meridian.*

This agreement as to boundary was drawn up from information laid down upon Vancouver's chart, which represented a regular and continuous range of coast mountains. Recent observations have disproved this theory, and shown the mountains to be not only broken

*Goldthwaite's Geographical Magazine, January 1891, page 67, Report of Expedition of 1890.

and irregular, but between the St. Elias and the Fairweather Ranges the ground becomes rolling and completely cut through by the Alseck River, which Mr. E. J. Glave and Jack Dalton, his companion, so fearlessly descended by canoe and by raft, over rapids, falls and the many difficulties and dangers of an unknown, barren and unexplored country.*

Besides the importance of the subject in the boundary question, the height and position of St. Elias is of much popular interest, and scientists and the general public are anxious to see it scaled, and all doubt set at rest concerning the true height. The various measurements are tabulated below as follows :

HEIGHT AND POSITION OF MT. ST. ELIAS.†

Date.	Authority.	Height.	Latitude.	Longitude.
1786	La Perouse	12,672 ft.	60° 15′ 00″	140° 10′ 00′
1791	Malaspina	17,851 "	60° 17′ 35″	140 52′ 17″
1794	Vancouver		60° 22′ 30″	140° 39′ 00″
1847	Russian Hydrographic chart 1378	17,850 "	60° 21′ 00	141° 00′ 00″
1847	Tebenkoff (notes)	16,938 "	60° 22′ 36″	140° 54′ 00″
1849	Tebenkoff, Chart VII	16,938 "	60° 21′ 30″	140 54′ 00″
	Bach. Can. Inseln	16,758 "	60° 17′ 30″	140° 51′ 00″
1872	English Adm., Chart 2172	14,970 "	60° 21′ 00″	141° 00′ 00″
1874	U. S. Coast Survey	19,500±500 ft.	60° 20′ 45″	141° 00′ 12′
1890‡	Nat. Geographic Society and U. S. Geological Survey	15,350 ft.	60° 12′ 00″	140° 46′ 00″
1891	Nat. Geographic Society and U. S. Geological Survey	18,100±100 ft.	60 17′ 51″	140° 55′ 30″

In discussing the above results, the first point to be considered is the method used in taking the observations and means to counteract refraction, an element which throws so much doubt upon trigonometric determinations of heights where the sides of the open triangles are so long, and where conditions are so utterly distinct and

*See Frank Leslies' Weekly (various sketches during 1891).
†Tabulated by Dr. W. H. Dall, except 1890 and 1891.
‡First Report, approximate. Second Report, 16,700 feet.

different between a station at sea level and a station on the summit of a great peak.

Referring to the work of 1874, we find that Dr. W. H. Dall in an able and exhaustive discussion, places the height at 19,500±500 feet, *i. e.* the probable error is 500 feet. Looking over this result carefully, we cannot but admire the intricate astronomic calculation through which a result is obtained from such meagre data and also from the uncommon method used. The position is fixed by horizontal angles connected with Azimuth line at Port Mulgrave, and by Azimuth observations taken directly to the peak from a point at sea, the position of which was determined by sextant.

In the discussion of this data we read as follows concerning the classes of vertical angles for elevation.*

"The first of these comprise sextant angles. Except under favorable circumstances and especially unless within a short distance of the object measured I do not consider these of any great value. The uncertainties of position and refraction are so great as to render the result in most cases of only the most general character."

Looking over this result and realizing that one point only of observation is on land and the other end far out at sea, and these two points not intervisible, we are led to conclude, notwithstanding the unobserved angle being nearly 60 degrees, that the limit of error given here is too small, and that a closer approximation to the truth would be ±1500 feet.

Data from which observations previous to 1874 were obtained is not available, and it is therefore impossible to refer to it. Results must be taken without question, the authorities mentioned being responsible, but as the vertical angle taken by Malaspina in 1791 agrees closely with that of 1874, and the general topography delineated in the former chart is also comparatively reliable, we would attach more weight to the result of Malaspina than to any of the other earlier measurements.

Had the scheme of work of 1890† been carried out as intended, the result of that season would have had more weight than any other, but the loss of the transit instrument made recourse to a less accurate one necessary, and many stations were interpolated by the three point problem. However, all meander stations were cut in from secondary stations. The checks obtained by vertical back angles as well as cistern barometer observations referred to a base station

*See report of Superintendent of U. S. Coast Survey for 1875. Appendix 10.
†See National Geographic Magazine, Vol. 3, Page 195. Report of Mark B. Kerr.

St. Elias
1 Intersection by plotting outside Lines.
2 Intersection by plotting inside Lines. (Position adopted Report Russell.)
3 Position by increasing Angle at Elias (unobserved) to 6.
St. Elias
Diagram as published in Russell's Report.
W.B.
E.B.
E.B.
16876 ft.
Scale 6 miles = 1 inch.

at sea level where readings were recorded regularly throughout the whole season, would naturally give much weight to the result. And again a system of triangulation was carried inland as far as possible, and surface measurements made to check meanders. One measurement for height upon Elias, was made from a station 4,800 feet above sea level, the latter determined both by angulation and by cistern barometer.* This station was 9.65 miles distant from Mt. St. Elias, and would give much more value than other observations taken from greater distances.†

The report upon the height of St. Elias,‡ recently published, proves that the theories of the expedition of 1890, were correct, and adds many new and interesting facts concerning glaciers and ice erosion. In the first place, the plot of the triangulation not being drawn to any scale gives an impression, without an inspection, of a much larger unobserved angle at St. Elias than is actually the case.

A true plot of this figure shows how much the horizontal distance is decreased by even a slight increase in the unobserved angle at Elias (see position 3 in diagram). Now plot the greatest and the least readings of the Azimuth circle, intersect these lines from the ends of the base and combine this difference in position with the probable error ± one minute noted in readings

*See Goldthwaite's Geographical Magazine, Vol. 1, Page 67.
†The two measurements of height of station differed by only 44 feet.
‡See National Geographic Magazine, Vol. 3, Pages 231—237. Report of I. C. Russell.

of the vertical arc. The result shows at once a much greater probable error in elevation than 100 feet, and consequent error in position (see positions 1 and 2 in diagram). To prove this more clearly the reader is referred to two tables, as follows:

I. Being resulting angles and computation of distances obtained from work of 1891.

II. Being computations of the height of Elias from three positions already referred to which show a range as follows:

West Base from 16,438 feet to 18,926 feet.

East Base from 16,462 feet to 18,940 feet.

Taking these results into account, as well as the great distance of the base stations from the peak, the different temperatures, atmospheric changes, and uncertainty of refraction, we are led to the conclusion at once that the possible error of 100 feet is too small.

If the base could have been extended by triangulation to two convenient points and the elevations actually determined both by cistern barometer and reciprocal angles, a coëfficient of refraction could have been obtained, and observations taken closer to the peak, as well as Azimuth observations from the two ends of the base, but this was not down, unfortunately.

The computation also of the geographic position of Mt. St. Elias, using the Azimuth and angle of elevation obtained at Port Mulgrave by the U. S. Coast and Geodetic Survey in 1874, combined with elevation obtained by the expedition of 1891, is open to much criticism as a crude and unreliable method, and very little weight can be given to the result.

It is not my intention to enter into further discussion of the uncertainty of trigonometric measurements for heights where distances between stations are so great, and especially so when it is impossible to obtain reciprocal zenith distances or at least a series of observations on different days.

In my own experience in topographic surveying in California and the West, I have had to throw out vertical angles very often when horizontal distances were much over 12 miles, simply because the atmosphere and relative refraction were so different at the two stations. In this case we were then forced to depend on cistern barometer observations, taking corrections for relative humidity. This was found to be entirely satisfactory, and I am sure most topographers will bear me out in this statement. So in discussing the results from which these various measurements have been obtained, we must consider also the great difference of elevation and

TABLE I.

RESULTING ANGLES.*

WESTERN BASE.				EASTERN BASE.			
	Right Vernier.	Left Vernier.	Corrected Vertical Angle.		Right Vernier.	Left Vernier.	Corrected Vert. Angle.
1	98° 31′	98° 32′	+5° 43′	1	76° 07′	76° 08′	+5° 37′
2	98 32	98 30	+5 43	2	76 07	76 07	+5 37
3	98 29	98 29	+5 43	3	76 06	76 07	+5 37
4	98 29	98 28	+5 43	4	76 07	76 08	+5 37
5	98 29	98 27	+5 43	5	76 07		+5 37
6	98 30	98 30	+5 43	6	76 07	76 08	+5 37
7	98 30		+5 43	7	76 07		
8	98 25	98 27	+5 43				
	98° 29′ 22″	98° 29′ 00″			76° 6′ 51″	76° 07′ 36″	
Mean	98° 29′ 12″		+5° 43′		76° 07′ 10″		+5° 37′

COMPUTATION OF DISTANCES.*

Distance East Base — West Base = 16,876 feet.

Station.	Angle.	Computation in feet. Log.
St. Elias.....	5° 23′ 38″	A. C. Log. Sine..... .....= 1.026 862
West Base.....	98 29 12	Log. Sine.....= 9.995 218
East Base	76 07 10	Log. Sine. .....= 9.987 129
		Log. Distance, E. B.—W. B..... 4.227 270
		St. Elias—West Base.... .....= 5.241 261
		St. Elias—East Base.....= 5.249 350

* National Geographic Magazine, Vol. III, pp. 234, 235—Report of I. C. Russell.

TABLE II.

COMPUTATION OF HEIGHT FROM THREE POSITIONS.

Western Base.	1 = 34.50 miles.	2 = 33.01 miles.	3 = 30.10 miles.
Log. Dist. Elias—W. B. (in feet).....	5.260 453	5.241 280	5.201 200
Log. Tan. Angle of Elev. = +5° 43'..	9.000 465	9.000 465	9.000 465
Log. Difference of Elevation.....	4.260 918	4.241 745	4.201 665
Difference of Elevation.....	18,235 ft.	17,448 ft.	15,910 ft.
*Correction, Curvature, and Refraction	+ 681 "	+ 623 "	+ 518 "
West Base above Sea.....	+ 10 "	+ 10 "	+ 10 "
	18,926 ft.	18,081 ft.	16,438 ft.

Eastern Base.	1 = 35.10 miles.	2 = 33.63 miles.	3 = 30.65 miles.
Log. Dist. Elias—E. B. (in feet).....	5.267 941	5.249 361	5.209 064
Log. Tan. Angle of Elev. = +5° 37'..	8.992 750	8.992 750	8.992 750
Log. Difference of Elevation.....	4.260 691	4.242 111	4.201 814
Difference in Elevation.....	18,226 ft.	17,462 ft.	15,915 ft.
*Correction, Curvature, and Refraction	+ 704 "	+ 646 "	+ 537 "
East Base above Sea.....	+ 10 "	+ 10 "	+ 10 "
	18,940 ft.	18,118 ft.	16,462 ft.

conditions existing between the stations, and must realize that "the increase of temperature with altitude causes an unusually rapid decrease of density in the atmosphere with a corresponding increase in refraction, thus producing the mirage so common here. It is noticeable only when both the observer and object are in the cold layer. A ray of light may reach the observer after following a horizontal path or after raising slightly, then being refracted down again. The result is to make the object appear stretched out and give it increased height."†

*4-7 sq. distance in miles.

†Report on Muir Glacier, by Prof. Harry Fielding Reid, National Geographic Magazine.

Summing up all the data available and proofs at hand we are thus led to believe that the preponderance of evidence points to the highest elevation recorded as being too great, and the lowest as being underestimated.

A mean of all the observations taken upon St. Elias gives a result of 16,693 feet, and the writer is inclined to the belief that its true elevation, when determined, will not vary much from this mean.

The rocks of the St. Elias region all indicate a recent origin. The only fossils found were upon the western crest of the Pinnacle Pass Hills, about 20 miles from St. Elias, and at an elevation of 5,000 feet above the sea. They were identified by Prof. I. C. Russell* as Mollusca. A few fossil plants from the same locality were afterward identified by Prof. Lester F. Ward, as Salix-California, and are found in the auriferous deposits of the Sierra Nevada. The subsidiary ranges are of shale and sandstone, and we saw crystallized rocks only upon the summits of the range.

No indication whatever of volcanic activity was noted, but one day as we saw an immense cloud of dust arise as the avalanches of ice and rock rushed down the slope of St. Elias, Cook, and Augusta, we could readily imagine how observers from great distances had mistaken this for the smoke from a volcano.

A great many observations have been made and articles written on the effect upon the system of rarefied air. In the summer of 1886 I camped six days and nights upon the summit of Mt. Shasta, part of the time alone and in a snow storm. The only trouble I experienced was a decrease in power of exertion, physical capacity, and shortness of breath. I had a poor appetite the whole time, and a little nausea, but I think the air from the sulphuretted hydrogen springs near by had more to do with my inconvenience than the altitude.

At Mt. St. Elias we were one month continuously upon glaciers at various heights. Once only were we troubled, and that with snow blindness. We were climbing up an ice fall where the huge detached ice masses were separated by deep crevasses. The blue goggles cast such a heavy shadow as to render our jumping over these crevasses rather precarious. As they were numerous, broken, and irregular, we took off our glasses, and that evening had a severe attack of snow blindness, and we nursed our eyes for twenty-four hours.

*Geologist in charge of expedition of 1890 and 1891.

At the Equator, it is stated, that high elevations produce amiability and entirely remove combativeness. It seems to me that this spirit or temperament changes with the latitude, for the bump of combativeness was strongly developed in our small party, which increases proportionally I should say, from the equator northward, as the square of the distance.

Extended field topographic work was stopped by a snow storm. After many days of travel over the ice, crossing crevasses by narrow and precarious bridges of snow, climbing up ice falls, roped together to prevent slipping, we had reached a glacial lake where the old icy bottom of deep azure gave a beautiful tint to the water. The elevation was 8,000 feet above the sea. We decided to leave our tent here and make a rush for the peak.

Very early on the morning of August 22d, 1890, we started and made the first thousand feet in a little over an hour. Crevasses did not interfere with us and we made rapid progress over the surface of the frozen snow. Our aim was to reach the divide between Newton and St. Elias, camp there over night, and then make a rush for the summit.

We were then beneath the first precipice of St. Elias. The rock was steep and bare and we could readily identify its nature. The summits of this great range are of schist, which conclusion we had already reached, having found specimens amongst the debris brought down by the glaciers to the sea.

At this point of our ascent the snow began to fall. Thinking it best to await a clear day for observation upon the summit, we cached our instruments near the cliff and between two huge crevasses, and returned to our lower camp.

We made ourselves as comfortable as four men could, crowded into a 7×7 tent, out upon a glacier in a snow storm and with short rations. I awoke quite early, and was surprised to find the snow had drifted, almost covering our tent, and found that $2\frac{1}{2}$ to 3 feet had fallen on a level during the night, and the storm still raged.

On account of short rations we determined to descend to a lower camp and make a new start, but storm succeeded storm, and although two desperate efforts were made, we never succeeded in again reaching our cache beneath the divide. I was caught upon the glacier during one of these storms, and passed three anxious days and nights alone, without fire and without blankets, with only a rubber blanket for shelter, until relieved by my companions.

My imagination pictured the instrument and a brick of alluminium given us to place upon the summit, first forming a little mound covered by thick-falling snow-flakes, then a drift, and finally completely obliterated, gradually carried along by the icy river, and mingling with the morainal debris, given off in future ages as a relic of past civilization.

The peak is accessible from the saddle between St. Elias and Newton, and all that is required to "get there" is first skill in mountaineering, and then grit, nerve and unswerving determination. Enthusiastic mountain climbers should not therefore wait for more perfected methods of astronomic calculation for height from a safe distance, but should take matters in their own hands, and endeavor to eliminate all doubtful results by carrying boiling-point tests and barometric work direct to the summit of the huge pyramid, to the honor and glory of the doers of such a deed, and for the increase and diffusion of geographic knowledge.

REGULAR MEETING, SEPTEMBER 2nd, 1892.

PROCEEDINGS.

MINUTES.

The meeting was called to order by the President, Mr. John Richards.

The minutes of the last regular meeting were read and approved.

The following new members, having been balloted for, were declared elected:

H. E. Clermont Feusier, U. S. Geological Survey..San Francisco, Cal.
William A. Doble, Mechanical Engineer.....San Francisco, Cal.

The following names were proposed for membership, and referred to the Executive Committee:

F. H. Carsson, Civil Engineer, San Francisco; proposed by C. E. Grunsky, Geo. F. Schild and Otto von Geldern.

Homer Perry, Mechanical Engineer, San Francisco; proposed by Byron Jackson, H. C. Behr and John Richards.

Mr. Mark B. Kerr then read a paper entitled the "Geographical Position and Height of Mount St. Elias," in connection with which he related some very interesting experiences encountered while making an ascent of the mountain, while engaged in taking observations for the U. S. Geological Survey. A number of lantern slides were exhibited, showing Elias from various directions and heights, and illustrating the vicinity of the mountain, and its prominent glaciers and moraines.

The discussions of the papers, read at the last meeting, being in order, it was agreed, upon motion, to postpone these discussions until the next regular meeting of the Society in order to give the members more time to prepare for the subjects under consideration; one being "Corliss Engines," read by John B. Pitchford, M. E., and the other "Elevator Tests," by Professor H. B. Gale.

Mr. C. E. Grunsky remarked that one of the papers of the Technical Society had been published by another serial before appearing in the Transactions of the Society, and that no credit had been given to the Society in this prepublication. He suggested that in

future the manuscript property of the Technical Society should not be allowed to appear in any other publication without consent, and that due credit should be given wherever copies of our original papers are made, either by extracting therefrom, or by republishing the whole. Mr. W. D. Johnson moved that the subject be referred to the Board of Directors for advice, which was done accordingly.

The matter of the Engineering Congress, to be held in Chicago in 1893, was brought up, and the proposition discussed as to the papers that would be submitted from the Pacific Coast on technical subjects.

In this connection Mr. Grunsky said that the Secretary of the American Society of Civil Engineers had written him to suggest the names of such parties who would be the most likely to present papers to the Congress on the most suitable subjects. He, as a committee from this Society, properly qualified, had suggested certain names and subjects, and the Secretary of the American Society had written him that the gentlemen, hereby proposed, had been duly notified of the object in view. The meeting in Chicago is to be held for one week only. Mr. Grunsky said that he would be pleased to receive any suggestion in regard to this matter, and that he would at once communicate with the Secretary of the American Society.

It was asked by Mr. Dickie that Mr. Grunsky communicate with the Secretary of the American Society of Civil Engineers, or with the Secretary of the Engineers' Congress, and ascertain whether the invitation to the Technical Society should not include all the members, and embrace the different engineering professions represented among them.

Adjourned. OTTO VON GELDERN, *Secretary.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

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NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

THE CLASSICS AND NATURAL SCIENCE AT A GERMAN GYMNASIUM.

BY C. A. STETEFELDT, Mem. Tech. Soc.

[Read October 7th, 1892.]

PREFACE.

During the years 1885 and 1886 a fierce war was waged in the colleges of this country, between the professors of the classics and of natural science. There was no blood spilled, but a great deal of ink. The professors of natural science asked for more appropriations to build physical, chemical, and biological laboratories, which demand was stoutly resisted, and declared superfluous by the professors of the classics.

Well, the men of science came out the victors, and received, in most places, what they wanted, and, thanks to the good sense of the majority of the college-trustees, they are receiving more support every day, as demonstrated, for instance, by the establishment of a school of electrical engineering at Columbia College, New York. The monthly periodicals of the country published, at the time, many papers to enlighten the public on the questions at issue, and my paper, *The Classics and Natural Science at a German Gymnasium*, appeared in the *School of Mines Quarterly*, July number, 1886.

Although there is a lull in the fight now, it is the duty of every scientist always to be alert. For this reason I consider it expedient to have my paper republished, together with some additions and a postscript, in which the question of education is treated from a historical standpoint.

The Gymnasium at Gotha had the reputation — and may have it now — of being one of the best schools in Germany. If instruction in the dead languages, almost to the exclusion of everything that is useful in life, is to be considered a measure of merit, the above-named school fully deserved this praise. At the time I entered the Gotha Gymnasium, in 1852, it counted among its professors two great philologists — Rost and Wüstemann. Rost, the director of the school, was a remarkable man. Besides being one of the first Greek scholars of his time, he was a man of broad culture, and even possessed such business qualifications that he occupied the position of president of one of the most prominent insurance companies in Germany. In contact with the students he was stern and severe, but just. He even went so far as to take the part of a student against a teacher, if he found that the former was right. We highly respected him, but I cannot say that he was loved. He inspired fear, but not hate. If he was in his wrath we trembled, and no one would dare to oppose him. Woe to him who was called upon to recite and found wanting! Such piercing sarcasm, such crushing invective would be rained upon his head that the poor fellow felt completely crushed. The Primus of the class once being called upon to recite, made rather a sorry mess in translating some lines of the Iliad. Rost asked him abruptly: "What do men carry upon their shoulders?" The student, being at a loss how to reply, kept silence. Rost answered: "A head, but you carry a wash-basin."

Rost's translations of the classics were marvels of originality, force, and beauty, and it is to be regretted that they have never appeared in print. In that respect the lessons were highly interesting; but there was too little of this. In one hour only a few lines of Homer, Sophokles, or Virgil would be translated, and the time was principally taken up with the dry syntax of a dead language, that left our minds void, and made us coincide with the monk's opinion that Greek was an invention of the devil.

In Selecta, the highest class, we had to write once a week a translation of German into Greek, dictated to us in German. The subject was invariably taken from a Greek author. Why this was done I do not understand, but my supposition is that even the best Greek scholar does not feel perfectly sure of avoiding mistakes. There were very few in the class who could accomplish this task without the most severe labor; hence, we worked on the co-operative plan. We had two students in the class who were well read

in Greek literature, and rarely failed to discover the author from whom the pensum was taken. Then the original was copied, taking care to avoid peculiarities of the author. Of course those who had the reputation of not being well up in Greek, inserted as many mistakes as they saw fit. Once it happened that a blockhead copied the author verbatim, and he was found out. Such a storm was rarely witnessed in the Selecta.

Wüstemann was the great Latin scholar, and Cicero was his ideal. His culture was all one-sided, and outside of classical literature and Roman antiquities, his mind was a blank. He could not even speak his mother-tongue with correctness and elegance. He was more at home in Pompeii and Herculaneum than in his native city. In his intercourse with the students he was as amiable and mild as Rost was gruff and stern. But there was much Ciceronian conceit and weakness in his character.

He amused us and we loved him. I cannot say that he taught us much Latin. It seemed to him almost a sin to translate Cicero's orations or the odes of Horace into German jargon. In case a student was called upon to recite and was not well prepared, he only needed to give a sign to the class. Thereupon we would commence to ask questions about Cicero in particular and about the Romans and Rome generally, and as he never failed to answer the most silly questions the hour passed most pleasantly. We asked him once how many hairs Cicero had on his head. Without considering the absurdity of such a question, he answered that Cicero was bald—there were not even the three hairs of the man of blood and iron. Upon being asked what language he thought the angels in heaven were speaking, he replied, with an injured look, "Latin, of course."

Subjects of great interest to us were the household affairs of the Roman ladies, and here Wüstemann was at home in every detail. He once gave to a number of friends a dinner á la Lucullus.

If we were bent on real mischief, we would ask questions relating to natural science. In that respect Plinius and Aristoteles formed the only stock of his information. His trusting disposition and shortsightedness often subjected him to impositions. I remember how a tall student announced that he had memorized one of Cicero's orations, and asked permission to recite it to the class. Boldly he mounted the rostrum, took an edition of Cicero out of his pocket, and read the oration with grand effect, to our amusement.

After he had finished he received a high compliment from the Professor. We were all sad when we followed Wüstemann to the grave.

The other professors of Latin and Greek were all of that dry quality that is characteristic of the majority of the philologists of a German Gymnasium, and classical schools generally. They never entered into the spirit of the author, but confined themselves to dry technicalities of the text. Many of us actually hated these lessons that seemed to be intended more to destroy than to awaken our intelligence.

Carlyle, in "Sartor Resartus," gives a sarcastic account of this system of instruction, as follows: "My teachers," says Professor Teufelsdröckh, "were hide-bound pedants, without knowledge of man's nature or boy's; or aught save their lexicons and quarterly account-books. Innumerable dead vocables (no dead language, for they themselves knew no language) they crammed into us, and called it fostering the growth of mind. How can an inanimate, mechanical Gerund-grinder, the like of whom will, in a subsequent century, be manufactured at Nürnberg out of wood and leather, foster the growth of anything; much more of mind, which grows, not like a vegetable (by having its roots littered with etymological compost) but like a spirit, by mysterious contact of spirit; thought kindling itself at the fire of living thought? How shall *he* give kindling, in whose own inward man there is no live coal, but all is burnt out to a dead grammatical cinder? The Hinterschlag professor knew syntax enough; and out of the human soul thus much: that it had a faculty called memory, and could be acted on through the muscular integument by appliance of birch-rods."

Our instructions in German and history, in the hands of Professor Regel, were excellent, and we all admired and loved this talented teacher.

In religion, we read the New Testament in Greek, but those not on the first bench preferred to read a novel or prepare themselves for the next lesson.

In French, we had a French professor, and a good deal of fun we had with him.

Mathematics we had very little, and only those who had a special aptitude for this science profited at all by these lessons. I have observed that, with rare exceptions, those students who excelled in Latin and Greek were the most backward in mathematics, and such instruction in natural science as we had. Since from

these students the professors of classics are recruited, it is not to be wondered that so little progress is made in improving the system of teaching in the Gymnasium. The instructions in natural science in the classes Selecta and Prima were confined to two hours of physics per week. They were abominable. The professor would read us the paragraphs from a text-book on experimental physics, but an experiment was never performed. Once a semester we were taken to a room called the "physical cabinet," where we beheld, awe-stricken, a collection of antiquated philosophical apparatus. We inspected it with the same curiosity that country-folks view a chamber of horrors, filled with instruments of torture from the time of the inquisition. There we were allowed to turn the crank of an electric machine, or beat the disc of an electrophor with a fox-tail. We were as ignorant about physics coming out as we were going in. But some of us went away with the impression that there were many things between heaven and earth of which our learned professors had never dreamed.

It is but just to say that since the Gotha Gymnasium has been combined with the "Realschule," the instructions in mathematics and natural science are carried on upon an entirely different basis, and more in accordance with modern requirements. I must finally state that the task imposed upon a student in a German Gymnasium is so onerous, especially as far as the classics are concerned, that were he to perform conscientiously all he is asked to do, he would break down, mentally and physically, in a year, even with an iron constitution. Hence, for self-preservation, he is forced to deceive his teachers. Surely, that must be injurious to the formation of character, and warp the morals of a weak mind. Why an intelligent people like the Germans allow such a state of affairs to continue, is a mystery.

Such was the condition of affairs when some restless spirits undertook to supply such mental food as the school considered superfluous to our training. The impulse to this step was given by some students of the Gymnasium at Eisenach, that beautiful city in Thuringia, at the foot of the Wartburg, where the minnesingers once reigned supreme, and where Luther translated the Bible. The Eisenach Gymnasium was still more given to an exclusively classical training than that of Gotha. Its bigoted director held the opinion, and openly expressed it, that anything outside of the classics was not worth knowing; that the study of natural science was pernicious to young minds, and would break up the discipline of

the school. When he discovered that students of the Gymnasium had formed a society for the cultivation of natural science, he threatened them with expulsion and demanded its immediate dissolution. But the brave fellows were not frightened by such threats. Persecution in a just cause produces redoubled zeal, and stimulates propagation of ideas. The immediate outcome was the formation of a society similar to that of Eisenach by students of the Gotha Gymnasium. On the 12th of June, 1855, six of us founded the "Naturwissenschaftliche Verein der Gymnasiasten zu Gotha." On the 14th of June the first regular session took place, and the president elect, Blau, delivered an address — strange to say — in Latin. Such was still the ban the classics held over us! This practice, however, was not continued, and subsequent presidents of the Verein, like myself, considered German more appropriate. The experience of our fellow-students at Eisenbach made us careful to keep the existence of our society a profound secret. Like a persecuted religious sect, we assembled privately. To do so for any length of time was not practicable. Hence, we concluded to reveal the existence of the Verein to the professor of mathematics and physics, the only one from whom we might expect encouragement and support. Now our by-laws had to be placed before director Rost. After two days of suspense he appeared in the classes of Prima and Selecta, and not only gave his approval, but praised us for what we had done. He warned us, however, not to neglect our regular studies, and expressed a hope that a society would be formed for the cultivation of the classics also. We had good reason to be proud of our director. The Verein was now actually under the patronage of the Gymnasium, and what such an eminent man as Rost had sanctioned, could not very well be undone by any of his successors. The Verein had members and associates. Each member would select a branch of natural science that suited his taste, upon which he would deliver a course of lectures. We were all self-taught professors instructing each other. I, for instance, delivered a full course of lectures on experimental chemistry, with experiments, and not without them like our professor of physics.

I must state here that our self-imposed task in delivering these lectures was by no means light. In order to prepare them properly the members of the Verein had to stay away frequently from class-recitations, feigning sickness, and working hard all day at home. Living in private quarters by myself, and without restraint, my

health, after the formation of the Verein, became apparently very poor. My accommodating landlord never refused to take a sick-note to the school. Professor Wüstemann, being a personal friend of my father, frequently visited me when I was reported a sufferer from disease. But the simple-hearted, kind professor never failed to announce to the class his intended visit. Then a member of the Verein came quickly to my quarters giving the signal of danger. Down went the curtain to hide the table with chemical apparatus. Next, the volumes of a fine, old edition of Cicero's orations, bound in "Schweinsleder," were placed on a table near the bed, together with a Latin lexicon. Now, quickly to bed with a handkerchief tied around the head. When the professor arrived he found the student with a volume of Cicero in hand, the serious crisis of the sickness having passed. How it pleased the professor to find me reading his beloved Cicero! The visit lasted about a quarter of an hour, during which the professor aided in translating a difficult passage. Then came a quick transformation of the scene: Down went Cicero; up went the chemical curtain, and the work of "fostering the growth of mind" was eagerly resumed. Happy days!

Hofrath Jacobs, the renowned artist, whose son was one of the most active members of the Verein, and whose grandson is a member now, placed a room in his residence at our disposition, where we held our meetings. Here we assembled once a week, holding a session of two or three hours. Special meetings took place besides. We soon accumulated a library of scientific works, and collections of philosophical apparatus, minerals, chemicals, plants, etc., were started, many donations being received from patrons of the Verein.

At the end of the year 1855, our active members had increased to nine. A lively correspondence with our Eisenach fellow-students was kept up. Besides the regular courses of lectures on chemistry, physics, geology, mineralogy, and zoology, papers on special subjects were presented and new books reviewed. The anniversary of the Verein was always celebrated with great solemnity, and generally took place in one of the beautiful nooks of the Thurgia forest, where the members of the Eisenach Verein often joined us. Those members who had left the Gymnasium and entered the university, would, during the vacations, attend our meetings and continue to further the interests of the Verein. This custom has been kept up to this day. On the 14th of September, 1869, the Verein celebrated the centennial anniversary of Humboldt's birthday with an oration.

Upon Dr. Peterman's request a collection was taken up for the German North Pole Expedition.

In 1863 I emigrated to the United States, and in practicing my profession as mining engineer in the West, I had completely lost track of the Verein. Most agreeably was I surprised when, in 1880, I received in San Francisco a letter from Gotha containing an invitation to the celebration of the twenty-fifth anniversary of the Verein. The institution I had assisted in founding had now reached the respectable age of a quarter of a century.

The Verein exists today and is in a flourishing condition. It has a library of over four hundred volumes, and keeps the most important scientific periodicals. Its collections have grown wonderfully. Its members have access to the astronomical observatory at Gotha, where formerly the renowned Hansen presided. Of its twelve active members two are sons of old members. Professors of the Gymnasium, some of whom are old members, visit the weekly meetings occasionally, and are always present at extraordinary meetings and celebrations. Professor Otto Burbach, Curator of the Gotha Museum, is the special patron of the Verein, and lends a helping hand whenever necessary. The theory of the Eisenach Gymnasium director that the study of natural science is pernicious to young minds has found no favor in Gotha.

I cannot neglect to mention an incident at the Gymnasium that influenced the career of several members of the Verein. After Wüstemann's death Professor Berger became the principal instructor of Latin in the class Selecta. We had once a week disputations in Latin upon some thesis chosen by one of the students. I selected as my thesis: "The study of mathematics and natural science is superior in training the mind to the study of the dead languages."

Thirty years ago it was risky in Germany to hold such an opinion, and sacrilege for a student of a Gymnasium to express it. The class was struck with awe by such temerity, and only the members of the Verein applauded, while the professor, pale with rage, left his seat to begin and carry on the disputation in person. The Latin of the members of the Verein was like that of the monks of the Middle Ages, very forcible, but somewhat ungrammatical and lacking Ciceronian elegance. So far as the linguistic part of the controversy was concerned we acknowledged our defeat, but as to the logic we claimed the victory. The senseless rage of our professor was a strong argument in our favor. After this my position in the class became decidedly uncomfortable. The professors of the

classics considered me a "black sheep," and feared that my revolutionary ideas might spread. I saw there was no use in remaining longer at the Gymnasium, or to make an effort to pass the abiturium. At the end of the semester I left for the University of Goettingen, being well prepared, thanks to the Verein, to enter upon the study of natural science. Rost, who was a personal friend of my father, conceded that I was right, and dismissed me with a flattering testimonial. Professor Berger was right also. The seed I had sown bore fruit, and the precedent I had created was followed by three others, who left the Gymnasium also without taking its full course. One of them, I am sorry to say, became an apostate, and after tasting a semester of academic freedom, returned to the Gymnasium, repentant, to cram himself with more Latin and Greek, pass the abiturium, and return to the university to study law. I am sure, however, that the knowledge he acquired through the Verein has benefited him in his practice as a lawyer.

My readers may now very properly ask the questions: What good has the Verein done? In what way have its members profited by it? Have they made successful careers in life? Would it have been as well if the Verein had never existed? To understand an answer to these questions fully it is necessary to be familiar with certain phases of German life. The students who are educated at a German Gymnasium, and take the full course of its instructions, generally go to the university to study either theology, law, philosophy and languages, or medicine, with the expectation of entering the government service. In a small principality like Gotha, the number of men who aspire to fill government positions is in excess of the demand, much more so than in the German Empire as a whole. Ministers, teachers of high-schools, officers of the civil service, lawyers, and physicians, prefer to send their sons to the universities to choose one of the professions, or "Brodstudien," in place of educating them for a commercial or technical career, partly because it is the custom, partly through mistaken pride. Any movement that would direct even a small number to leave the beaten track, and induce them to become chemists, geologists, metallurgists, mining engineers, etc., would not only improve the individual chances of these men in the race of life, but leave more breathing-room for the others, especially as the former were forced to seek employment abroad, the limited industries at home (I mean in the principality of Gotha) being insufficient to utilize their services. This is exactly what the Verein

has done. We have not been so fortunate as to produce a Humboldt or a Darwin, but the Verein counts many old members who occupy honorable positions and who rank above the average. In proof of this it was my intention to give a complete list of the old members of the Verein and state what has become of them. This, however, I found to be a most difficult task, as most of them had left home and are scattered all over the world. Even at the twenty-fifth anniversary of the Verein only a portion of the old members could be reached. This in itself is a proof that the Verein has been instrumental in inducing its members to break the narrow barriers of the fatherland and seek a field of usefulness in the world at large. That the existence of the Verein has been the means of influencing the career of many of its members, and has widened the intellectual horizon of all of them, cannot be denied. That it still continues to exert this influence is evident from the fact that nearly all the members of the Verein who left the Gymnasium the present and the past year have chosen a study, and will follow professions, connected with natural science. Professor Burbach informs me that by 15 of these students the following selections have been made: 3 natural science, 4 medicine, 1 forestry, 3 civil and mechanical engineering, 2 engineer corps of the army, 1 modern languages, 1 theology and philosophy.

POSTSCRIPT.

At the time when copies of the above paper reached Gotha, the Verein was in great danger. Our much respected Rost had long ago crossed the Styx, and a man of inferior understanding had taken his place. Some members of the Verein had violated the laws of the school — perhaps by indulging in a "Kneipabend"— and in place of punishing them as individuals the learned director concluding that "the study of natural science was pernicious to young minds, and would break up the discipline of the school," suspended the Verein with the intention of abolishing it altogether. At this critical moment a copy of my paper was given to the director by one of the professors of the Gymnasium who had been a member of the Verein. When the director read the words "what such an eminent man as Rost had sanctioned could not very well be undone by any of his successors" he paused, and the Verein was permitted to exist. Thus the publication of my paper did a service which it was not expected to perform.

The question may be asked: What part will the classics play in the education of future generations? A radical change cannot be expected in this generation, because the brains of "the powers that are" are too much befogged with the utility of the present system. Too many men are still living who foolishly glory in their having received a classical education, although they know only a few Latin and Greek vocables, and never could read the Iliad or the odes of Horace with fluency.

Students of classical schools, three hundred years ago, actually acquired the use of the old languages, and wrote and spoke Latin at least fluently. But at this day, from the ages of eight to eighteen or twenty, they are taught the syntax of Latin and Greek, but no language. How many men at the age of forty, who have graduated from a classical school, can translate a passage from Sophokles, or write a letter in Latin? All the profit we gain from this classical waste of time at college is that we know the meaning of scientific terms derived from Latin or Greek — with the aid of a lexicon; or as my friend Professor Hesse very pointedly puts it: "The principal advantage I derived from the study of Greek is that I know the letters of the Greek alphabet."

There was a time when the genius of man found expression almost exclusively in sculpture and poetry. His must be a dull mind, indeed, who looks upon the Apollon Belvedere, the Aphrodite of Melos, or the Aphrodite de Medici, and fails to realize that *here* the perfection of the sculptor's art had been reached, never to be surpassed or even equalled in ages to come. Less marked in excellence were the productions of poetry; but the grand epos of the blind poet, and the tragedies of Sophokles and Æschylos will be read so long as the human race exists. Also the philosophical and historical writings of the ancients were of a high order, and Aristoteles has been justly called the father of natural science.

Then came a time when the classical ship was blown about on a rough sea, and finally foundered on the rock of Saint Peter. Now, men's minds were given only to religious thought, and in attempting to save their own souls and those of their neighbors, they succeeded admirably in creating a hell on earth. But when the Church of Rome gained immense power, and accumulated great wealth, the popes and the Roman prelates commenced to lead lives of luxury, pleasure, and vice, finding the discussion of religious dogmas insipid. This led to the Renaissance of art, poetry and literature. While the sculptures of even a Michael Angelo never

approached the Greek ideal, the art of painting — of which the ancients had only known the rudiments — reached its zenith. Architecture had already, about two centuries prior to the culmination of the period of the Renaissance, reached its highest ideal, and the grandeur of the Christian religion had found expression in the Gothic Cathedral.

His must be a dull mind, indeed, who can behold the divine Madonnas of Raphael and Holbein at the Dresden gallery, and not acknowledge that *here* the genius of man has left productions, the perfection of which will never be surpassed by generations to come. The wife of the San Francisco millionaire was right, and she showed an intuitive appreciation of art, when she insisted that none but one of the *old masters* should paint the portrait of her beautiful daughter.

Then *again* came a time when men's minds became insane with religion. The paint on Raphael's canvases and frescoes, which adorned the Vatican, was still fresh when the Reformation threw the whole civized world into the turmoil of war, bloodshed, and torture. But one great boon was given to mankind—*the Liberty of Thought*—such as it was at the time; and a genius, born long ago in Greece, but thus far suppressed by Christian fanaticism, modestly raised his head — *Natural Science.*

The Church of Rome had found it expedient, in order to preserve its authority, not to permit the promulgation of ideas conflicting with the most absurd statements contained in the Bible. Natural science was considered the enemy of the Church, and its promulgation made a crime, punishable by execution at the stake. While the Protestant Church claimed liberty of thought for itself, it begrudged this boon to scientific men, who were, however, tolerated to a certain extent, but not encouraged. In matters of education, which was entirely controlled by the Church, Catholic or Protestant, the classics reigned supreme, and natural science played no part whatever. Education meant a classical education, and men of science used Latin exclusively in their publications. Hence, the use of Latin and Greek vocables, often a barbarous combination of the two languages, in scientific nomenclature, which custom prevails today, and will probably do so forever.

It would be unjust to find fault with the classical schools of the time to which I refer. The poetry and literature of the ancients, which, to this day, we acknowledge as our models, formed *then* the principal stock of information for educational purposes. Latin was then the language of the theologian, the philosopher, the scientist,

and of all cultured people, just as French, in the past century, was the language of the diplomats, the courts, and of polite society all over Europe. You will recollect that even Alexander von Humboldt wrote a part of his works in French. It cannot be denied that the use of Latin by scientific men of all European countries was of considerable advantage.

In proportion as, in subsequent centuries, the power of the Church waned, and the supremacy of the State increased, education became more and more secular; and natural science, finding itself free from the irksome restrictions and persecutions of the Church, made progress with enormous strides.*

There *is* a time *now* when natural science reigns supreme, and throws in the shade art, poetry, literature, and everything else. At last we have *unrestricted Liberty of Thought.*

Thousands of busy brains are gathering and recording facts in all branches of science, which has differentiated in an embarrassing degree; but few are the master-minds able to form universal laws. We are all working to reach one great goal: To find *the One Law of Motion*, which governs the universe, life included.

Although the human brain is composed of many millions of cells, endowed with thousands of functions, its powers are finite in regard to the absorption and reproduction of ideas. Why, then, should a part of this priceless organ be all burnt out in early youth to a dead grammatical cinder by littering it with etymological compost? Why should youths, between the ages of eight and eighteen or twenty, be left to the mercy of hide-bound classical pedants, at a time when the brain grows and is most apt to receive impressions? Would it not be a blessing if all these gerund-grinders were shipped to the South Sea Islands, and there fed to the end of their natural lives on stewed Greek particles and broiled irregular verbs?†

Then, and *only* then, will we reach our goal; a master-mind will rise and formulate that *One Law of Motion* to which every atom of the universe responds, and which will be so simple that the average brain cannot fail to comprehend it.

*It is not necessary here, for sake of the argument, to sketch in detail the progress of art, literature, and science from the time of the Reformation to the present; but if we ask: What is the greatest achievement of the human mind in modern times? The reply is — *Darwinism.*

†It is hardly necessary to state that I do not mean this literally. Men devoting themselves to scientific research should know the Greek alphabet, and they should be taught in their early youth sufficient Latin as a foundation for the easy acquirement of those modern languages, the roots of which are derived from Latin. Since scientific men have abandoned the Latin tongue as a means of exchanging ideas, it becomes necessary for them to be familiar with several of the modern languages.

DISCUSSION.

PROFESSOR CHARLES D. MARX.— "I must confess I was very much interested in the historical review which Mr. Stetefeldt gave us in his paper. I, myself, had the opportunity of testing at a somewhat later period the advancement which has been made in the curriculum of the German schools. It was my fortune in 1870 to attend a school in Germany where a great many of the defects he has cited as existing in the old system have been avoided. He speaks of the curriculum as then consisting mainly of the classics, this is true at the present time, but to a more limited extent. More stress is laid on modern lines of thought, and a good deal upon the study of mathematics and the study of natural sciences. It is interesting to notice that these are being recognized more and more in Germany. The Emperor (erratic as he may be considered) favors these lines of instruction, and he recognizes the fact that we ought to be living more in the present and less in the past.

Mr. Stetefeldt's review is interesting, and it must be valuable to us in this country. There are certain important lessons for every country to learn that has not a definite system of education, and it is but natural that they should turn to other countries which have well developed systems as their source of information.

We all probably recognize the fact that in the earlier development of American education it was customary to follow the system of education of other countries, especially of Germany. I think it is fully recognized at the present time, that the conditions here are somewhat different from those in the older countries, and that we must find our solution along our own lines. I believe that the system of education which we are working out at present in our own country, will ultimately lead to more satisfactory results.

In Germany it is almost a necessity that one should study the classical languages, because the only chance for preferment lies along certain lines, and young men are compelled to study the classics in order to enter the professions. It is not possible for a man to study medicine at the University who has not completed his course at the Gymnasium. Of course, every man is anxious to have the largest choice of a profession at the time he decides to enter upon some career. Under these circumstances it is quite apparent why, in Germany, they pursue the study of the classical languages.

In this country we are more liberal, and it is not considered important for a civil engineer to be able to read Cicero or Virgil.

I am free to say that our development is a much more rational one. I think that a little sentence which Dr. Jordan is often in the habit of quoting, expresses the present condition of the development of most of our American Universities: 'the air of liberty is abroad — it is blowing.'

I think most of us have seen the dangers which Mr. Stetefeldt has so clearly pointed out tonight, and that we are walking along the paths that he and others made for us so many years ago."

MR. STETEFELDT.— "A great many years ago when this question of classics and natural science was discussed in Germany, the advocates of the classics went to work in a very ingenious way and got up statistics which showed that all the eminent men the country had produced had been at the Gymnasium. This was very stupid and very unfair, because if a man in Germany wants to occupy any prominent position, if he wants to go into the civil service of the Government, or desires to become a lawyer, a doctor or a professor he is forced to go to the Gymnasium — there is no other course left to him. Consequently the best talent went to the Gymnasium—not that the Gymnasium produced it."

PROF. SMITH.— "I quite agree with what has been said. Of course the study of the classics has been urged as a factor in culture, and in the development of character, but I believe it is the attitude of professors of Latin and Greek in our best institutions that they do not want men to come into their classes unless they come of their own free will. I believe the most advanced men who are teaching Latin and Greek do not hold that these studies should be required in the college curriculum.

I am inclined to quote a little statement made by Professor Sweet to his class at Cornell University some years ago, where he was a teacher. 'The world will not pay you for what you know, but for what you are able to do.' A man may acquire all the wisdom of all the ages, and yet he may die and the world not miss him. But if he can make use of his knowledge and benefit mankind, the world is further along for it. This is a matter which needs to be considered by a young man in shaping his course.

I do not set up the study of the natural sciences as preëminent and above all other things; I believe every young man and woman who is preparing for a life of usefulness ought to be allowed to select that line of work which they prefer. So I believe that the elective system is the proper one, and that by and by there will be no opposition between different departments of study, and each person will pursue that line which they naturally prefer."

DR. BEHR.— "I perfectly agree with the views that have been so completely expressed by my friend Mr. Stetefeldt. I know very well that a great deal of valuable time is lost by the study of the classics. But there is a tendency of going too far and abolishing Latin altogether in our universities. Latin is the neutral ground where all nations meet. Scientific literature would require the study of a dozen languages, where now a knowledge of Latin is sufficient. Unfortunately, some of the sciences have outgrown the Latin, which would not have been the case if Latin had been allowed to grow with them. Of course, that cannot be remedied now; but I am very much in favor of keeping the Latin in all biological branches as long as possible, until in course of time it is replaced by a modern language that has taken universal sway.

GEORGE W. DICKIE.— "I want to preface my remarks by saying that I believe in classical education for one reason; I think if all our professional men had to study the classics there would not so many of them get through. The sentiment of poetry and that sort of thing is being crushed out, and is not getting a fair chance. I go through dry specifications from morning until night, and I often wish just for the sake of variety some fellow would get up a specification in rhyme or blank verse. I think it would be a good thing for our architects and engineers, and people of this class, to go way back and gather up what they can find among the ancients. Now, when we get down to a scientific basis for anything, we get down to facts, and there are not enough facts to go round we need to indulge a little in imagination. The poetry is going out of our business. Straight lines and direct strains are getting to be monotonous. By all means let us have the classics — let us have it all. They are grinding out so many students, at these polytechnic schools and colleges for the study of the sciences, that we are overrun with them. I am glad I got into the business when they were studying the classics and nothing else. If they did then as they are doing now I would be very badly off.

The paper is very interesting indeed, although I think it is a little one-sided. We ought, by all means, to hold on to the classics, especially in engineering. I don't know how far back the ancient history of engineering goes, but we have reached a time when we look back at what they were doing fifty or sixty years ago in mechanical engineering, and it is ancient history, has a language of its own, a principle of its own, a shape of its own, and we have got out of it. If we could now put some imagination and poetry

into what we make, we might sell it for ornament when otherwise it would not sell at all."

PROF. KEITH.— "Science has advanced so fast that it almost makes a language of its own. If we used Latin we would need a new lexicon, and, like Webster's dictionary, it would become an immense volume. While the studies of the ancient languages and the classics have their place, and should be open to those who desire to pursue them, science really develops faster than the language can advance. We coin and compound new words, which are set aside in a short time because too long to express the idea, and a new and briefer word is substituted. The idea goes with the word. Then why should we, in this age of rapid advancement, be held back by the necessity of expressing our ideas in a dead language?

It is the rubbing of one fact against another that produces a third, and if all had to be published in German, or in English, or French, or Latin, or Greek, we would find that those who originate these ideas, and who are making these advances in the arts and sciences, would not express them, because they do not wait for the information that has gone before — they start out in new lines of their own, and after the facts are discovered, the theory and the talk about it is to be performed. Modern papers are written in the language of those who have the idea, or who have experimented and brought out the facts, and published in the language with which they are familiar, and with which they can fully express what they wish to convey. To be sure, it is a hindrance to publish in different languages, but at the same time the ideas are preserved, and the translations are made and widely circulated. Most of those who study Latin in the schools do not remember it, and they are compelled to express themselves in the language with which they are familiar, and even then they find it necessary to continually add new words to properly express new discoveries and things connected with them."

REGULAR MEETING, OCTOBER 7th, 1892.

PROCEEDINGS.

MINUTES.

The meeting was called to order at 8:30 P. M. by the President, Mr. John Richards.

The minutes of the last regular meeting were read and approved.

The following new members, having been balloted for, were declared elected :

F. H. Carsson, Civil Engineer.....San Francisco, Cal.
Homer Perry, Mechanical Engineer.....San Francisco, Cal.

The following name was proposed for membership, and referred to the Executive Committee :

Mr. H. I. Randall, B. S., Instructor of Civil Engineering, University of California ; proposed by Prof. Frank Soulé, Adolph Lietz and Otto von Geldern.

The following communication was submitted and read by the Secretary :

" The Committee, appointed on July 1st, to draught a memorial to the memory of the late Andrew Fraser, of this City, and a member, of this Society, submits the following :

The removal from our midst of an active member, in the prime of life, endowed with high attainments and personal qualities of every commendable kind, is an event that demands our solemn consideration, and condolence with those more nearly connected in a personal way with our lost member.

That such a life as his, richly stored with the useful and good — a work of fifty years to build up — should be destroyed in an instant by an assassin's hand, with no incentive but a few paltry dollars on his person, is a sad commentary on the uncertainty of life and the inefficiency of safeguards to protect it.

The Chairman of your Committee, who was intimately connected with Mr. Fraser, and who, perhaps, more than any other member of this Society, has felt his loss, and can best bear witness to his many

good qualities, is glad of this opportunity to join in a tribute to his memory.

Mr. Fraser's career has been one of activity and usefulness. It is familiar to our members and needs no recital here. Your Committee is merely to put into words the sentiments of the Technical Society of the Pacific Coast respecting their lost member and associate, and to offer condolence and sympathy with his many friends, who will be interested in knowing his standard and relations here. This we have briefly done in such form as our feelings have dictated, and as is here submitted."

R. S. MOORE,
Chairman.
L. C. RUSSELL,
E. A. RIX.

Upon motion the report of the Committee was received, placed on file, and a copy thereof ordered to be sent to the family of the deceased member.

Mr. C. A. Stetefeldt then read an interesting paper entitled "Curriculum of a Modern College; Classics *versus* Natural Sciences" relating in particular the conditions existing at the old German Gymnasium, referring to his personal experience while a student at the Gotha Gymnasium, and the founding of a society for the cultivation of natural sciences among the students, which to this day has been continued as one of the most prosperous institutions of that character in Germany.

Remarks were made in connection with the important subject of classics in college, by Prof. Chas. D. Marx, Prof. Smith, Dr. Behr, E. J. Molera, Geo. W. Dickie, N. S. Keith, and others.

Adjourned.

OTTO VON GELDERN, *Secretary.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

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NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

CLIMATIC FEATURES OF THE PACIFIC SLOPE.

ESPECIALLY CALIFORNIA, AND THEIR RELATION TO ATMOSPHERIC CONDITIONS OVER THE PLATEAU REGIONS.

[Illustrated with Stereoptican Views.]

BY LIEUTENANT JOHN P. FINLEY, U. S. ARMY.

[Read November 4, 1892.]

The weather of any place is the sum of its transient meteorological phenomena. To find the sum of such occurrences in California will require more than ordinary calculation. In other words there is variety in her weather as there is diversity in her industries. To understand these varying conditions one must consider, at least, the following important general features: (1) The great extent of latitude embraced by the State. (2) Its pronounced topographic outlines. (3) Its position relative to the North Pacific Cyclone Belt. (4) Its relation to the Japan and Alaskan currents of the North Pacific.

To comprehend the meteorology of such a region one must become impressed with the necessity of extending the investigation far beyond the limits of the State. Surrounding atmospheric conditions for hundreds of miles must be closely watched to discover the source of those phases of cloud and sky which

indicate the progress of peculiar systems of circulating air, under the influence of solar radiation and of the axial rotation of the earth, and which bring over large areas of country, changes in temperature and variations of precipitation affecting the prosperity of thousands of square miles of territory. One cannot study weather understandingly from his own doorstep.

Because of California's great extent of territory north and south she feels the effect of tropical influences as well as those of the temperate zone. Coupled with her varied topography, unequaled in the United States, the fluctuations of atmospheric pressure within the limits of the North Pacific Cyclone Belt give rise to some anomalies in weather, both extremely interesting and complicated. Why wonder at the results, with a surface contour affording extraordinary differences in elevation, from nearly 300 feet below to about 15,000 feet above sea level, permitting variations in temperature from torrid heat to Arctic cold, and changes in atmospheric humidity, from the driest areas on the continent to the saturation of a tropical clime. The most skilled meteorologist will find ample scope for the exercise of his knowledge and professional training.

Being at one season largely within and at another largely without the predominating influence of cyclonic disturbances, introduces peculiarities of weather and climate which distinguishes the meteorology of California from that of any other portion of the United States.

The proximity of two ocean currents essentially different as to temperature, course of movement and atmospheric effect, gives rise to a coast climate remarkably at variance with that of the interior valleys only a few miles away, and still different from the adjacent mountain districts. No state in the Union is so uniquely situated, so diversified as to climate and weather within such circumscribed limits.

All the various local and secondary causes are largely subservient to one superior and overwhelming influence, the action of the North Pacific Cyclone Belt.

The meteorology of the State as a whole, as well as of localities, falls under the sway of this power. The notion must be discarded, that the weather of California is not dependent upon atmospheric conditions over adjacent regions to great distances, especially over states to the east and north. This dependence arises from the fact that these adjacent states are nearer and therefore more strongly affected by the passage of cyclonic disturbances. All

of these disturbances enter upon the coast from the North Pacific Ocean. They are huge atmospheric eddies which have developed in the air resting upon the warm waters of the Japan Current. The typhoon of the China and Japan Seas becomes, later on in its course, the cyclonic disturbance which sweeps across British Columbia, thence to the region of the Great Lakes and further on to the Atlantic and Europe.

All cyclones cross the United States at a lower latitude in winter than in summer. This condition results, in part, from the apparent movement of the sun north and south of the equator, whereby the area of heat and moisture of the temperate zone reaches a higher latitude in summer and recedes to a lower latitude in winter. The atmospheric eddies enter the continent at about the 50th parallel, being about the latitude of the center of the northern portion of the Japan Current, which flows eastward from the Asiatic Coast. The fluctuations of the Cyclone Belt north and south on the Pacific Coast depends then upon the change in the location of the areas of heat and moisture. These two elements constitute the food of cyclonic disturbances, and without an almost unlimited source of supply areas of low barometric pressure begin to fill up and disappear. Clouds and rain, with boisterous winds, are soon followed by clear, calm weather and a dry, cool atmosphere.

To understand the distribution of precipitation over any region one must clearly comprehend the essential characteristics of a cyclonic disturbance. Such information is especially necessary regarding the rainfall in California, for its occurrence and distribution are peculiar and unlike, in some respects, that of any other state.

As cyclonic disturbances may vary in diameter from 500 to 1,500 miles, and the centers invariably move eastward, north of San Francisco, it would rarely, if ever, occur that the whole of any area could be shown on a chart of the Pacific Slope. From the Pacific to the Mississippi Valley the direction is a little south of east. From that river to the Atlantic the course is somewhat north of east. The forms of cyclonic areas are either elliptical or circular, and the former predominates on the Pacific Coast. The isobaric line of 30.00 inches marks the separation between the two principal classes of atmospheric disturbances, viz., the cyclone (low), and the anticyclone (high).

An observant "new arrival" is not long in discovering that California has, during the year, two weather periods instead of four,

known as the "wet season" and the "dry season." He learns that they are powerful factors in determining the prosperity of the commonwealth. When Nature, in a kind mood, arranges the relation of these two seasons with a marked uniformity of variations, then Dame Fortune smiles upon the commercial and agricultural interests of the State. If the exact character of these seasons could be forecasted in advance, what enormous profits could be realized. Such long-range prognostications have never been vouchsafed to man, and there is no immediate prospect of his acquiring such extraordinary knowledge. We must be content, for the present at least, with a much more limited degree of information, but yet not lacking in practical importance.

The two meteorological seasons of California are dependent for their proximate occurrence upon the distribution and frequency of cyclonic disturbances between the 40th and 50th parallels, and the rate of progress eastward, together with the energy displayed between the Pacific Ocean and the 100th meridian. In short, the cyclones move farther south and are of greater energy in winter (the wet season) than in summer (the dry season). A careful examination of the charts in the office of the Weather Bureau will show very clearly that the weather over any region depends upon the relation of the latter to the quadrants of the passing cyclone or anti-cyclonic disturbance. According to the quadrants which pass over any region, so will be the successive phases of weather therein.

All forms of atmospheric precipitation are distributed over the earth through the agency of these systems of air circulation. They are of enormous extent and great power, drawing moisture from all available sources, carrying it to great heights in the atmosphere, where, by a marked change in its surroundings, the vapor is transformed into water, and falls again upon the earth. The physical forces of evaporation and condensation cannot fulfill their mission in the production of atmospheric precipitation without the assistance of adequate means for setting up and maintaining a system of circulation for the distribution of the vapor of water throughout the lower regions of the atmosphere.

It has been found that these atmospheric eddies pursue certain paths over the continent of North America. There are two such lines of travel, one along the northern boundary of the United States, and the other from the West Indies northwestward to the Gulf States, curving northward at the 30th parallel of north latitude, and moving thence northeastward over the Atlantic Coast

States. The second path joins with the first one near Nova Scotia, where, together, they form a well-beaten path along the 45th parallel, of all cyclonic disturbances crossing to Europe.

It is a fact to which attention has not been especially drawn, that that portion of the United States most distant from the influence of the atmospheric eddies, which travel the two storm paths, embraces the arid section, or what is known as the middle and southern plateau regions. They include southeastern California, Nevada, Utah, Arizona, New Mexico, western Colorado, and southern Wyoming. This may be called the dry region of the United States. It is well known as the region of least rainfall, and has been found to be the region over which the greatest atmospheric evaporation (about 100 inches annually) takes place. There can be no doubt that the meteorology and climatology of this region depends most largely upon its geographical position regarding the cyclonic belts over the United States. California's share in this relationship cannot be understood without a comprehensive and graphic view of the whole situation.

We must already begin to see some evidence of the preponderating influence of the northern storm belt in the distribution of precipitation over the United States, and especially the Pacific Slope. Of course all general and predominating influences are counteracted here and there by local differences, which, in this discussion, may be briefly referred to as topographical. The limits of this paper will not permit of considering this branch of the subject particularly. The dry region of the United States can never be other than it is, so far as atmospheric conditions are concerned, without a great physical change, which would completely reverse the circulation of the Japan Current in the North Pacific Ocean, and bring it nearer the California Coast. It must needs bathe this Coast as does the Gulf Stream the coast of the South and Middle Atlantic States. Then would the dry region become, in weather and climate, and in vegetation, as that of the Gulf and South Atlantic States.

We find that the weather of California, like that of any other region, is dependent upon the atmospheric conditions surrounding it for hundreds of miles. If it were nearer the cyclone belts, its two famous seasons, the "wet" and the "dry," would be changed into a more uniform distribution of precipitation throughout the year, and a less uniform distribution of temperature. Such a modification of its climate would be detrimental to some of California's greatest industrial pursuits. Its variety of weather and climate is now unrivaled

in the United States, and therefore the peculiar adaptability of the State for the growth of the choicest fruits, grasses and cereals. Its geographical position is such that the seasonal fluctuation of the North Pacific Cyclone Belt carries the rain area far to the north, and protects the crops that would otherwise suffer severely from heavy cloudiness and drenching rains.

The precipitation of the "wet season," when the Cyclone Belt takes a more southerly course, is generally heavy; and there is stored in the earth a supply of moisture that frequently goes far towards supplying the needs of summer. When this source fails, resort must be had to either surface or sub-irrigation, but the "dry season" in California does not mean an entire absence of rain throughout the entire state. Rains occur on the northwest coast from San Francisco northward, and in the mountains in the northeast and southeast portions during the summer. They are frequently heavy with thunder storms in the southeast portion. The central valleys are the dryest in summer, especially in July and August, where in some places no rain falls during those months for a period of several years. In any case only the lightest showers occur at long intervals, resulting from the drifting over and settling down into the valleys of heavy clouds from the mountains. Such precipitation is likely to occur when the snows of the previous winter have been heavy and the mountains remain snow-capped throughout the year.

The heaviest precipitation occurs in the mountains, diminishing rapidly to the valleys, and becoming least on the Mojave and Colorado deserts. The average depth of snowfall in the mountain districts is a very important factor in forecasting the rains for July and August, and ascertaining the probable water supply for irrigating purposes. Heavy snow in the mountains in winter will result in "cloud bursts" in the high plateaus in summer. The enormous extent of surface covered with snow, from a few inches to many feet in depth, offers an extraordinary opportunity for rapid evaporation under the burning rays of the morning sun, through a clear, crisp atmosphere. Heavy clouds appear over the lofty ranges by about 12 noon, and when the sun begins his downward course, and the air currents are pushing down the mountain, great masses of clouds are hurled together and carried over the valleys, attended by smart showers and occasional manifestations of atmospheric electricity. Here we have a brief view of the conditions under which summer rains occur in the mountain districts of California, especially in the

southeastern portion of the state, and the adjacent regions of Nevada and Arizona. Even these may be called cyclonic rains, for they invariably occur under the influence of a barometic trough of low pressure, covering the eastern portion of the Pacific States and the plateau regions, the center of the cyclonic disturbance being in British Columbia, north of Montana. The effect of this trough may not disappear until the central area moves eastward into Dakota and Minnesota, like a monstrous sea serpent slowly dragging his tail.

A low barometic pressure is especially favorable to evaporation and the development of ascensional air currents, which force great quantities of vapor of water into the air, and rapidly condense it into clouds. Clouds consist of small drops of water, light enough to float in the air. Fogs are clouds resting upon or very near to the surface of the earth. When the drops of water become large enough and sufficiently heavy to fall to the earth they are called, collectively, rain. I have quickly depicted here the transitions from water, in the liquid and solid state, through the vapor or gaseous form, to the liquid state again. What a powerful engine is the atmosphere, and how nicely adjusted must be all the cogs, wheels, springs and compensations of this exquisite piece of machinery that it never wears out nor breaks down, nor fails to do its work at the right time and in the right way.

The effect of the fluctuation of the North Pacific Cyclone Belt is also shown in the probability of rainy days for various parts of the State, and in the percentage of clear and cloudy days. The probability of rain for the valleys is proportionately much lower in summer than the probability of cloud formation. This is largely due to the fact that while the northward deflection of the Cyclone Belt is sufficient to prevent rain it does not remove the influence of cyclonic circulation in the production of cloud formation. At times the sky will remain overcast for several days and pass away without precipitation. The condensation has not been sufficiently vigorous under cyclonic circulation to develop drops of water of sufficient size to fall to the earth.

Tabulated statistics furnish interesting and valuable data for comparative climatic study, and show the importance of systematic meteorological investigation. The public generally are not able to realize the vast amount of labor in computations, and the long years of constant watching, secretly represented by a little collection of figures. It is a patient but determined study of Nature, who refuses to reveal herself without the most ingenious and prolonged effort of man.

No portion of the United States offers richer opportunities for meteorological research, or will afford greater practical results from thorough and systematic investigation, than the weather and climate of California. No state is in greater need of such scientific inquiry; and if successfully prosecuted it will greatly aid in the development of her rich resources. It will bring them to the attention of thousands who would be glad to enjoy the fruits of "perpetual summer;" the opportunities of a wonderfully varied climate and soil; the invigorating influence of unsurpassed mountain and air scenery; and the advantages of marked uniformity of temperature along a coast line of marvelous extent and diversity.

Theoretically California should furnish the best and most varied health resorts and sanitariums in the United States. Within her borders most every form of wasting disease should find the means of temporary, if not permanent, relief. While our present knowledge warrants this assumption, yet practically the truth of this statement in all necessary details must be developed and tested by adequate scientific research.

The agricultural, horticultural and commercial interests must be more fully informed as to the probabilities before them, and every line of industry afforded the means of weighing thoroughly its chances for growth and success. A reliable knowledge of probable weather changes and climatic effects is rapidly becoming a daily necessity in all occupations.

In illustrating the subject of this lecture the views are classified with the purpose of proceeding in their presentation from general atmospheric disturbances to those of a local nature, as indicated in the following order of arrangement:

1. General Atmospheric Disturbances.
2. Local Atmospheric Disturbances.
3. Destructive Effects of Tornadoes.
4. Mountain Meteorological Stations.

List and Description of Stereoptican Slides.

1. General Circulation of the atmosphere.
2. Typical cyclonic circulation.
3. Typical anti-cyclonic circulation.
4. Vertical section of cyclone showing wind system.
5. Vertical section of cyclone showing depression of barometer.
6. An anti-cyclonic wave of barometic pressure.

7. Cyclone of December 8th, 1886, central over the British Islands, and which swept them with great violence. On the southeast side the gradient of the barometer was one inch in two hundred and forty miles. Velocity of wind ranged from 50 to nearly 100 miles per hour during the passage of the storm.

8. Center of low barometer in a tropical cyclone, Northern Hemisphere.

9. Tracks of cyclones over South Pacific Ocean, Southern Hemisphere.

10. Cyclonic storm tracks in the North Pacific.

11. Paths of storm frequency in North America with distribution of rainfall.

12. Storm paths (Pacific Coast) dry season.

13. Storm paths (Pacific Coast) wet season.

14. Cyclonic storm tracks over the North Atlantic during October.

15. Cyclonic storm tracks over the North Atlantic during June.

16. Tracks of West India hurricanes for over 100 years.

17. Tracks of hurricanes over the Gulf of Mexico for over 60 years.

18. Distribution of atmospheric pressure during blizzard of January 9th, 1886. Wind velocity on Mt. Washington, N. W., 122 miles per hour. Block Island, 64 N. E. Boston, 64 N. E. Eastport, 60 N. E. Snow reported over 20 feet deep in many valleys throughout the Dakotas. All trains blockaded throughout the Northwest. Heaviest snowfall in years. Severe cold-wave east of the 100th meridian. Millions of dollars of damage to orange trees in Florida. Cold norther in Texas, with high winds, snow, and a fall in temperature of from 30 to 60 degrees in 24 hours. At Pensacola, Florida, bay frozen over from shore to shore. Hundreds of fish paralyzed with cold and easily caught. Fort Elliott, Texas, 14,000 head of cattle frozen. Charleston, S. C. several persons froze to death. Gainesville, Ga., two degrees below zero, and in vicinity seven degrees below. Ground froze 18 to 20 inches. In Northwest temperature fell 30 to over 50 degrees below zero. Fort Benton 51 degrees below zero.

19. Heavy snowdrifts on Madison Ave., New York City, after the Blizzard.

20. Topographical relief map of California.

21. Rise and fall of temperature attending the passage of a cyclonic area.

22. Atmospheric circulation during the formation of a mass of cumulus cloud.

23. Distribution of atmospheric pressure over the Pacific Coast States giving rise to a hot norther in Southern California on June 10th, 1877. Los Angeles, 101 on the 8th ; 103, 9th ; 104, 10th ; 112, 11th. Cajon Rancjo, 107, 9th ; 112, 10th. Holloways, 105, 11th. Spring Valley, 111 to 122, 11th. Campo, 101, 11th. Stanwix, 108, 11th. Yuma, 114, 12th. Stanwix, 110, 12th. Maricopa Wells, 110, 12th. Wickenburg, 108, 12th. Camp Verde, 104, 12th. Campo, Tucson, Phœnix and Florence, 100, 12th. San Francisco, 92, 11th. San Diego, 93, 9th.

24. Distribution of atmospheric pressure giving rise to heavy fog along the coast of Northern California.

25. The cold wave of January 14th, 1888, in California. The most severe since the memorable one of January 5th, 1854. Ice two inches thick at Sacramento. Temperature fell to 13 degrees below freezing. Truckee, Cal., 25 degrees below zero. Marysville 12 degrees below freezing.

26. California rains with extended barometic trough, May 3rd, 1892.

27. Cold wester of May 15th, 1883, in California.

28. Chinook of January 18th, 1892, in Idaho and Montana. The chinooks of the northwestern part of the United States are similar in their effects to the foehn of Switzerland, and the zonda of the Argentine Republic. In North Greenland and along Smith Sound a warm southeaster has been reported in the middle of winter. The change of temperature in case of perfectly dry air is one degree for each 183 feet, cooler with ascent, and warmer with descent. Air descending from an elevation of 4,000 feet may receive an increment temperature of over 20 degrees. At the same time its capacity for moisture is increased, and it will be felt as a dry, hot wind.

29. Thermograph record of rise and fall in temperature at Fort Assinaboine, Montana, noon of January 18th to noon of January 19th, 1892. Rise of 43 degrees in 15 minutes.

30. Movement of clouds over the Sierra Nevadas from an elevation of about 10,600 feet in the vicinity of Round Top. The photo was taken from Main Triangulation Station, Round Top, in the crest line of the Sierra Nevadas, at 10,600 feet above the sea, looking toward the east. The mountains in the distance, visible in places through the clouds, are in Nevada, and from forty to more than sixty miles distant. Their elevation reaches 10,000 feet.

The distance of Round Top from the ocean is 160 miles. The time of year was early in October.

31. Clouds floating over the Equator.

32. The trade wind belt clouds of the North Atlantic.

33. Clouds at noon day over the summit of Mount Washington.

34. Cloud scene from the summit of the Himalayas.

35. Cloud scene, Eaton Canyon, Mount Wilson, Southern California.

36. Geographical distribution of tornadoes over the United States for a period of 200 years.

37. Incipient formation of tornado cloud, showing upward currents from the surface of the earth.

38. Incipient tornado clouds seen at Delphos, Saline Co., Kansas, on May 30th, 1879.

39. Path of the great cyclonic storm of February 19th, 1884, with attendant tornado tracks.

40. Geographical distribution of the areas of warm and cold air during the tornadoes of February 19th, 1884.

41. Tornado cloud seen near Howard, Minor Co., South Dakota, on August 28th, 1884. Ten people killed, and all property in the path of the storm destroyed.

42. Tornado cloud passing within about five miles of Garnett, Kansas, at 5:30 P. M., on April 26th, 1884.

43. Tornado cloud, New Ulm, Minn., June 10th, 1883.

44. Tornado at Wilkesbarre, Pa., August 10th, 1890, scene on South Main Street.

45. Lawrence tornado. House bottom side up.

46. Tornado at Grinnell, Iowa, June 17th, 1882. Freight train blown off the track and overturned.

47. Destruction of Pennsylvania Chemical and Salt Works, Philadelphia, August 3rd, 1885.

48. Tornado, Grinnell, Iowa, June 17, 1882.

49. Destruction of Steamer Major Reybold on Delaware River at Camden, August 3rd, 1885.

50. Another view of Steamer Reybold, showing destruction of smokestacks.

51. Tornado at Walterborough, S. C., April 16th, 1879. Ten persons killed, and 75 wounded; 50 buildings destroyed.

52. Tornado at Grinnell, Iowa, June 17th, 1882. Ruins of Dr. Grinnell's residence.

53. Lawrence Tornado. Great destruction of residences.

54. Tornado at Camden, N. J., August 3rd, 1885. Penn. R. R. Co's. round house.

55. Tornado, Jamestown, Ohio, April 27th, 1884. Schoolhouse destroyed. 10 killed. Loss of property $200,000.

56. Louisville tornado. Destruction of the depot of the Louisville and Nashville Railroad.

57. Tornado cloud, North Vernon, Ind., June 10, 1883.

58. Tornado near Fairbault, Minn., July 20th, 1890.

59. Destruction of buildings at Brownsville, Saline Co., Mo., on April 18th, 1892.

60. Tornado, Grinnell, Iowa, June 17th, 1882. Ruins of residence of Geo. Parse. Six wounded. Mrs. Parse blown 500 feet.

61. Tornado cloud passing near Ercildoun, Penn., on July 1st, 1877. Five people killed, and 60 buildings destroyed, loss $40,000. One hundred people wounded.

62. Tornado in Morgan Co., Ill., on May 18th, 1883. Three persons killed, 25 wounded. Cars blown from the track and destroyed. Railroad track torn up in several places.

63. Tornado, Galesburg, Ill., June 15th, 1880.

64. Tornado, Grinnell, Iowa. Ruins of Dr. Ford's residence.

65. Tornado at Connorsville, Ind., May 14th, 1882. Freight train blown off the track and overturned.

66. Tornado and waterspout near Cleveland over Lake Erie, June 5th, 1864.

67. Tornado cloud, Ercildoun, Pa., July 1st, 1877.

68. Tornado, Grinnell, Iowa, June 17th, 1882. Destruction of buildings.

69. Tornado, Louisville, March 27th, 1890. Baxter Square.

70. Thunderstorm and lightning in Northern New York, June 23rd, 1883.

71. Forms of hailstorms.

72. The pampero of the Argentine Republic. The pamperos are southwest squalls coming off the pampas, or the extensive plains of the Argentine Republic. They are usually followed by a thunder storm and rain with decided falls in temperature, as much as 35 degrees in six hours, and are attended with a peculiar form of cloud wreath. These clouds have been seen fifty miles in length, and sometimes three of them in succession rushing forward, but with the regularity of battalions of soldiers. These clouds develop during the passage of a cyclonic storm eastward over the northern portion of the Republic. The clouds attending the storm are rolled into

this peculiar wreath by the winds suddenly shifting from the east, through the north, to west and southwest. The upper wind currents come from the northwest, preceding, during and after the pampero.

73. Lunar halo at Fort Conger, within the Arctic circle. Latitude 81–44, Longitude 64–45 W.

74. Heavy thunderstorm near Covington, Ohio, May 13th, 1886.

75. Terrible force of the wind at Rochester, Minn., August 21st., 1883. Straws driven into fence posts and trees.

76. Dust whirls in British India.

77. Large dust whirl in British India. The dust storm comes on without warning from any direction. A low bank of dark clouds is seen on the horizon, which rapidly increases, and, before the spectator is aware, the storm bursts upon him, wrapping everything in midnight darkness. Violent gusts or squalls succeed each other at short intervals, gradually becoming weaker, and at the close of the storm a fall of rain generally takes place. The air is often highly electrical.

78. United States Signal Service Station, Fort Conger, the Arctic Regions. Latitude 81–44 N., and Longitude 64–45 W.

79. Meteorology Observatory, Japonski Island, Sitka Harbor, Alaska, occupied by the Russians 1842 to 1867.

80. New quarters of the Central Office, U. S., Weather Bureau, Washington, D. C.

81. U. S. Signal Service Station, Mount Whitney, occupied by Prof. S. P. Langley in 1881. 14,887 feet above the sea level.

82. U. S. Signal Station, summit of Pike's Peak, Col., nearly 15,000 feet above the sea level. Continuously occupied by the Signal Service for fourteen years.

83. U. S. Signal Station, summit of Mt. Washington, 6,286 feet above the sea level.

84. French Meteorological Station on the summit of the Pic-du-Mide, 7,763 feet above sea level.

85. Cyclone on Virginia Coast, off Cape Henry, March 22nd, 1877. Signal Service Station communicating with the stranded steamer *Pantzer*, a Norwegian vessel, by means of international flags. During this same storm the U. S. war vessel *Huron* was wrecked.

86. Arctic Highlander from Cape York.

87. Rescue of Lieut. Greeley and his comrades at Cape Sabine, Smith Sound, in latitude 78 N., and longitude 74 W.

REGULAR MEETING, NOVEMBER 4th, 1892.

PROCEEDINGS.

MINUTES.

The meeting was called to order at 8:30 P. M. by the President, Mr. John Richards.

The minutes of the last regular meeting were read and approved.

The following new member, having been balloted for, was declared elected :

H. J. Randall, Instructor in Civil Engineering, University of California.

The following names were proposed for membership, and referred to the Executive Committee :

Wm. F. C. Hasson, Consulting Electrical and Mechanical Engineer, of San Francisco ; proposed by H. B. Gale, John Richards and Wm. A. Doble.

Frank E. Lesourd, Mechanical Engineer, of Portland, Oregon ; proposed by A. J. Brownlie, J. B. Pitchford and Otto von Geldern.

Albert W. Smith, Professor of Mechanical Engineering, Leland Stanford, Jr., University ; proposed by Chas. D. Marx, John Richards and Otto von Geldern.

Chas. B. Wing, Professor of Civil Engineering, Leland Stanford, Jr., University ; proposed by Chas. D. Marx, John Richards and Otto von Geldern.

Lieutenant Jno. P. Finley, U. S. Army, then delivered an address entitled "Climatic Features of the Pacific Slope, and their Relation to Atmospheric Condition over the Plateau Regions." This interesting discourse was illustrated by numerous lantern slides prepared for the purpose.

The following resolution was unanimously adopted, after some courteous remarks by Prof. H. B. Gale :

Resolved.— That the Technical Society of the Pacific Coast tenders to Lieut. J. P. Finley its sincere thanks for his kindly interest in the welfare of the Society, and for his valuable contributions to its records.

Adjourned.

OTTO VON GELDERN, *Secretary.*

REPORT OF THE FINANCE COMMITTEE.

Submitted to the Board of Directors, October 18th, 1892.

ASSETS ESTIMATED FOR JAN. 1, 1893.

Unpaid dues	$838 00
Estimated receipts from new members to Jan. 1st, 1893, fees	30 00
" " " " " " dues	12 00
Receipts from advertisements in Bulletin, 3 mos. @ $55.00.	165 00
Total estimated Assets, Jan. 1st, 1893	$1045 00
*Deduct for uncollectable dues	100 00
Estimated Assets, Jan. 1st, 1893	$945 00

LIABILITIES.

BILLS PAYABLE.

Spaulding & Co	$628 30
Britton & Rey	135 00
Industrial Publishing Co	309 37
Total Liabilities	$1072 67

ESTIMATED CURRENT MONTHLY EXPENSES.

Hall Rent	$40 00
Secretary	25 00
Average percentage on collections	15 00
Postage	10 00
Miscellaneous printing and stationery	12 00
Bulletins (printing)	60 00
Bulletins (engraving)	12 00
Short-hand Reporter	3 50
Miscellaneous	2 50
Janitor	2 50
Gas	1 00
Elevator Boy	1 00
Towel Company	1 00
Total estimated average monthly expenses	$185 50

*NOTE.—The item "Unpaid Dues" in above account, includes dues from members who are in arrears $10.00 or more. Of these members five have not paid the admission fees. The Committee therefore considers that a deduction of $100.00 should be made under the heading of Uncollectable Dues, making this correction in the above account.

FINANCIAL STATEMENT.

ESTIMATED FOR JANUARY 1, 1893.

	Dr.	Cr.
To bills payable	$1072 67	
To current expenditures to January 1, 1893, @ $185.50 per month	556 50	
By estimated accounts as per detailed statement		$945 00
	$1629 17	$945 00
	945 00	
Balance of indebtedness January 1, 1893	$684 17	

AVERAGE MONTHLY STATEMENT.

	Dr.	Cr.
To estimated current expenses	$185 50	
By dues from members (approximated)		$200 00
By receipts from advertisements in Bulletin		55 00
	$185 50	$255 00
		185 50
Monthly revenue that can be counted on to meet indebtedness		$69 50

As shown by the foregoing estimates of receipts and expenditures, we hope to fully pay outstanding accounts by Nov. 1st, 1893, or (by an estimated increase of revenue by fees and dues of 20 new members) by August 1st, 1893. In order to do this, however, it will be necessary to collect the dues from members in a better manner than has been done lately, and we advise therefore the employment of a regular collector.

To induce members to meet their obligations on the present occasion, we suggest the distribution of a circular containing an official notice that payments are now due, also a statement of the financial condition of the Society, and an appeal to the members to keep up the standing of the Society by paying their dues regularly. Perhaps members would pay more readily if dues were collected quarterly.

An attempt should also be made by the Secretary and the Executive Committee to reduce, if possible, the current expenses. Perhaps the items of postage and miscellaneous printing could be materially reduced. The monthly balloting for new members has

tended to increase these two items. Some societies, like the American Society of Mechanical Engineers, have quarterly elections.

The cost of printing and stationery could also be reduced by omitting the invitation cards to the monthly meetings, or, if cards are desirable, to print a large stock of these of some standard form, with blank space for writing the title of the paper, etc., which could be filled out by the members using these cards.

The notice of meetings should be sent out on postal cards, thereby saving envelopes and other stationery.

The item of engraving for our Bulletins should be reduced. The Executive Committee should inform the authors of papers before hand if they will allow anything for the proper engravings.

By economizing in the manner suggested in the foregoing we believe that the current monthly expenses could be reduced by from 15 to 25 dollars.

We also call attention to the diplomas, which have been issued at the request of a number of the members, and the cost of which, $85, forms an item of our indebtedness. Only 25 or 30 of the diplomas have been sold. Members should be notified of the existence of this diploma, and should be invited to procure one in order to pay off the indebtedness for the same.

In conclusion we suggest to the Board of Directors the expediency of drawing up a set of rules for guidance in the conduct of their business. We believe that the financial condition of the Society should be the first thing brought before the Board at every meeting.

The Secretary should have a list of those members who are in arrears with their dues. He should notify them of the fact and stop sending their Bulletins, stating the reason for so doing. Members in arrears over a certain amount should be notified that if they do not pay their dues they will be dropped from the membership list within a given time from the date of notice.

C. E. GRUNSKY
H. C. BEHR
A. SCHIERHOLZ
} *Finance Committee.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME IX. No. 11.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

GOVERNMENT AID AND CONTROL OF ROADS AND HIGHWAYS.

[Discussion, December 2d, 1892.]

The Technical Society having been requested in a circular letter, addressed by Albert A. Pope, of Boston, Mass., to obtain signatures to a certain petition praying Congress to found a public Department of Roads, the following discussion took place.

The attention having been called to the condititon of our public highways, their present state and improvement, Mr. Manson read the petition as circulated by Mr. Pope:

To The Honorable Senate and House of Representatives in Congress assembled.

"We, the undersigned, citizens of the United States, hereby most respectfully petition that there be founded in the city of Washington, in the District of Columbia, a Road Department, similar to the Agricultural Department, for the purpose of promoting knowledge in the art of constructing and maintaining roads; and we ask that in such department provision be made for teaching students so that they may become skilled road engineers.

In connection with this Road Department we request that there be established a permanent exhibit in which shall be shown sections of roads illustrating various methods of construction and also the best road materials and machinery.

We further petition that Congress appropriate funds sufficient to erect a building at the World's Columbian Exposition for the purpose of a comprehensive road exhibit."

The discussion of the subject was then opened by Mr. C. E. Grunsky, who said:

"Mr. President, I think that in connection with this communication there is but little to be said. It strikes me that what we need is the establishment of a department of this kind in every State of the United States, but in connection with every university in the land. Universities should lead in disseminating information relating to irrigation, drainage, and all subjects involving the welfare of the entire community. It behooves our universities to take the lead and draw attention to these matters, and make road construction (as I know they all do to some extent), a subject of paramount importance.

I do not see the necessity for a Federal Road Department. It would simply be a department for the few favored ones who reach Washington. It is a movement in the direction of centralization that I do not think is justified at the present time. We need the best facilities that can be had at the universities, and at as many points throughout the United States as possible. When it comes to the matter of road material and road construction, there is much to learn. I think we ought to begin at home and educate the public to use such material for roadbeds as is best adapted to the wear the road is subject to. Of course no two roads are subjected to exactly the same requirements. Street pavements, in cities, that are constructed on all manner of grades, require all manner of wearing surfaces. It rests with the technical expert to determine what these should be, and the engineer who plans them should devote due attention to proper drainage, and look after every detail as he does in any other work of engineering importance."

MR. MCCULLOUGH.—"Col. Pope, probably more than any other man in the United States, has worked in the interest of good roads, and in this proposition he aims to make this country like many of the old countries; he wants to have a department for everything, to centralize every interest in one part of the country. As Mr. Grunsky said, it is a matter for every State and County to look after. Nearly every university in the land is advertising special courses in road engineering; a great many schools are doing so. I think instead of signing a petition like this, that a movement should be made by our Society, and other similar ones, to interest the legislatures in this subject."

MR. WAGONER.—(Vice-President in the chair.) "I think some discussion as to how far the General Government ought to collect

data for such purpose would be in order. It is the opinion of the Chair that in that line useful work can be done. I would be pleased to hear from some of the gentlemen on that point."

MR. MANSON.—"I think the best way to disseminate knowledge in regard to good roads is in a series of university extension lectures. Such lectures have taken very well in the country, and have disseminated much beneficial information on a large number of subjects. We have not at the present time as full a development of this as there is in several other States. We have two large universities here, both of which are reasonably well endowed, and both of which have Chairs of Engineering, and if the Technical Society were to initiate the matter, they would start a series of lectures, or have a popular discussion on the subject, and have it distributed by the press. There is a great deal of information on the subject, and there is no necessity of having a great Bureau of Information by the Government. There is a library of such information in half a dozen different languages. I believe that as soon as the importance of good county roads shall have been presented to the people of the State, and the actual saving in dollars and cents by hauling over good roads as compared to hauling over bad ones has been demonstrated, that by bringing the subject before the people in that way, it will do vastly more good than if the Government were to collect information. As soon as the General Government undertakes to do anything, the people seem to look upon the Government as a sort of Hercules, and that all they have to do is to wait and let it do the work. I have in mind the case of a small river in West Virginia, which was in such a condition that boats had to be pushed by poles up and down the river. Petition after petition was sent to Congress to have the river improved. If the number of words spoken and written about it could have been put into dynamic force, it would have cleared the river of all obstacles. Finally Congress made an appropriation of a few thousand dollars. While the Government was taking out some of the snags and impediments, there were enough idle men looking on to have waded into the river and removed everything the Government did a dozen times over. Good roads are a benefit to the people, and I believe the people should put their own shoulders to the work.

If we can get our universities to extend their lectures in this line, and societies like our own take hold of it, and let bulletins or circulars (such as have been circulated here tonight in regard to the testing of wire and the strength of materials) be issued and placed

before the boards of supervisors and the people, showing what can be done, by that means I believe the people will be induced to go to work and make good roads. When the people realize the financial value of good roads to themselves, and that they are the most interested, I believe they will take hold of it and accomplish what is desired."

MR. MOLERA.—"I have occasion to travel a good deal over the country roads, and I know the way they are made. They try to build them with as little money as is possible. They generally give the contract to the man who is nearest the place where the road is to be built. I am afraid if a series of lectures were given to the people at large under the auspices of the universities, that there would be still more amateur engineering done in the counties than there is now. I think instead of that the opposite course should be pursued, and that this Society, and all the friends of this Society should join together and make it requisite in building roads to have the work planned and looked after by some one that has some knowledge of engineering. The lawyer or the physician has no right to practice except under the laws of the country, and the same restriction should apply to the civil engineer.

There is a road I travel frequently that is impossible to pass over without risk of life and limb, and hardly a week passes without some serious accident, and sometimes the accidents are fatal. I think we should not advocate the popularizing of how to build roads. Our country has very smart, bright people, and they need but little instruction to become experts in everything. I think it would be well to try and pass a law as this Society did in regard to allowing surveyors to make maps; they will not be considered official except when made by surveyors who have been subjected to an examination. Apply this very same thing to the building of roads."

MR. MANSON.—"Mr. Molera misunderstood my idea in regard to university extension lectures. It was not to make engineers out of every roadmaster that happened to be nearest to these roads to be built, but to exercise a certain missionary influence on the community, to let the public know how badly off they were, how easily they could improve their condition by the construction of better roads, and how much cheaper it would be, and the money they would save in the end. Of course they would have to employ competent people to do the engineering. The idea is not to make an engineer of every supervisor or roadmaster. I think we will have

to commence farther back than that. The resident in the country will see the importance of sending his boy to the university and training him so that he can come back to his county and be able to build good roads. In the meanwhile he will have to employ some members of our profession to look after the engineering part of their roads."

MR. WAGONER.—"I wish to say that behind it all we find the supervisors, and they are the men who order the roads built; they have the power to determine who is to build them, and no matter how many educated engineers and men skilled in road making there might be, unless there were some method of having these skilled persons employed, I don't see what object there would be in educating them."

MR. KOWER.—"They have a way in some of the countries in Europe of obviating all this trouble; that is, the State would aid a township or county to a certain amount. I have one case in mind where the State offered to bear one third of the cost, provided an engineer licensed by the State was employed in building the road. That would be one way out of it. There might be a law passed by which the State would aid the county in some such manner as this. I think the root of all this evil lies in the fact that a surveyor frequently makes the county roads. People would laugh at the idea of putting up a candidate for health officer who was not a physician. But we have men as superintendent of streets or road overseers, who have no idea of engineering. They may be very good surveyors, but certainly are not fit to be good road overseers."

MR. BUSH.—"It seems that the Technical Society is to take action. I suggest that they turn their attention to the legislature, and put their views in such shape that the road system may be taken out of politics. The county surveyors and the supervisors, or the persons who lay out the roads, get a valuation of the lands, and run the roads through the poorer portions of the ranches. Then the road masters or overseers are made collectors in their districts for the labor performed, and they are good helpers in election times. I think it would be a good thing to take the road question out of politics and put it in technical hands."

MR. HALL.—"This subject reminds me of the school department of this City; attempts have been made to take it out of politics, but the greater the attempt, the more 'pull' people had to get into that department. In my experience here, I have known men to be appointed as superintendent of streets, or overseers of work done by

contractors, who did not know anything at all of the work. I don't know how these matters are to be taken out of politics."

MR. SANDERS.— "I want to make a remark before the subject is dismissed. It can probably be divided into two branches. One is the education of the masses in regard to the necessity of building good roads; the other is the education of special and technical men who have the ability for this work.

I think it is a fact, well known to every engineer who has traveled much in America, that we have neglected both branches of this subject. I think the people, as a rule, are ignorant of the increased advantages which arise from having good roads, and they have not, as a rule, employed scientific and technical men to construct roads. Of course there are evils to be deplored in regard to the resolution that was read. It seems to savor of bureaucracy; it tends to centralize these things too much, and to take them away from the locality where they should be applied. This evil should be looked to and avoided.

One gentleman has suggested that we should impose severe restrictions in regard to the operation or care of engineering work, and see that men were specially qualified for it. In regard to the restrictions of the medical fraternity, and other branches of science, it seems this is opening the door to tremendous evils. If we are to have no limit to this sort of thing, we will have certain arbitrary methods which we will have to submit to and accept, and be at the mercy of the gentlemen who prescribe these things. If I have to receive my medical attendance from a certain school which the Government has picked out for me, and if I have to have my roads built according to some centralized bureau department, I don't know where it will stop; I will have to do everything according to some specific form. I am opposed to this sort of thing, I wish to see the line drawn. When we have educated the people in regard to good roads, and men are trained to build them, I think this thing will then come about naturally.

I think all of us agree that America has the poorest roads in the world. While this may be on account of the newness of the country, and simply due to a lack of time and wealth to make them by a judicious system which has not been put into operation, yet as has been suggested, it would be possible to carry the science and practice of road making ahead of the general diffusion of knowledge. I believe this is done in Europe. I do not believe the masses of the people in Europe are more intelligent on this sub-

ject than the people in America, yet the roads in Europe are given such care and attention not approximated in this country. In the Eastern States roads are much better than in the Western States.

Another point I would like to mention is the system by which these roads shall be paid for. Every question resolves at once into a question of finance. Whatever methods are adopted the roads have to be paid for, and that is a very important point to be considered. I mention these matters simply to call them to your attention."

Mr. Molera here moved that the Society take no action in regard to the communication, which motion was amended by Mr. Manson to the effect that the Secretary notify the sender of the communication and petition, that the Society does not approve of the Government establishing a Bureau of Road Construction.

This motion, embodied in the minutes of the meeting, was put by the Chair, and carried, as amended.

Mr. Johnson.— "I think it would be better for the Technical Society to take definite action on this subject. At the root of this whole matter is the important question of how far the Government should go in this direction. There will be one class who will advocate the extension of Federal authority very widely, another class will oppose it. In the history of the United States there has been a rapid growth of the Federal power, and in such matters as this it crops out. The tendency of one class is to put everything in the hands of the General Government, and the other to resist it. So the question of how far the Government should operate in the matter before us is a very important one. Now there seems to be something radically wrong in the establishment of schools under the National Government, for this reason, that there is naturally an aristocratic spirit which seems to attach to the graduate of such a school, which from his actual training he should not have.

But is there not in the machinery of the Government a very useful means for getting information? Instead of the establishment of a school for turning out graduates in highway engineering, would it not be better to put into the hands of Government the collection of information of a wide and general character, which could not be collected and grouped together piecemeal? I think the functions of the General Government should be more particularly of that character in such a matter as this, rather than in the training of individuals for actual work."

A TOPOGRAPHICAL MAP OF THE STATE OF CALIFORNIA.

[Discussion, December 2d, 1892.]

At the April meeting (1892) of the Society, Mr. Willard D. Johnson, of the U. S. Geological Survey, called the attention of the members to the fact that a movement had been started to make an extensive topographical survey of the State, and in order to carry out such work successfully, and to obtain the necessary State aid, the endorsement of the plan by scientific societies was suggested.

The address of Mr. Johnson is contained in the Transactions of the Society, April, 1892, p. 92. After his remarks, the Society moved to consider an endorsement of the plan as outlined by the author.

A committee of three was appointed, consisting of Messrs. Grunsky, Vischer, and Curtis, to confer with Mr. Johnson in effecting a plan of procedure, and to report in due time to the Society.

The present discussion of the subject turns upon the practical solution of this problem, and contains the opinions of the individual members, as to the details and cost of the proposed survey, and the practicability and usefulness of a map on a small scale, showing the contour lines and topographical features of the State of California.

MR. GRUNSKY.—"Mr. Johnson some months since spoke of the necessity of making a good map of the arable lands of the State, made on a contour plan, showing the elevations of the land and the topography, and the Society appointed a committee for the purpose of meeting in joint conference a number of other committees. We have had a number of such meetings, and the matter has been quite fully considered and discussed. But in order that the Society may fully understand the proposition, I would like to ask Mr. Johnson to give an explanation of the work itself."

MR. JOHNSON.—(After reading from a prepared paper certain data regarding the proposed work, contained in part in the address made before the Society at the April meeting, Mr. Johnson said:) "It is the aim of the Geological Survey to cover the entire field by a topographical survey, but this is a thing beyond the possibility of a lifetime of an individual to accomplish. The Geological Survey has worked in California on two classes of topographic

work. The earlier work done in California and elsewhere was called preliminary work ; it was made on a scale of an inch to four miles and arranged in atlas sheets. Those were contour maps, full of errors everywhere, but little errors. They represented the right number of mountain ranges, canyons and peaks, with the correct altitude of those peaks. This preliminary work was conducted until there was such a demand for topographical map work — that is, having seen what the map was like, the people having been educated to what a topographical map might become, and the use that it would serve ; they demanded a better one, and the standard work of the Geographical Survey got to be an inch to two miles. That, probably, will not be changed again. For the last eight years we have been working in this State on this scale. We have covered a very large area in California. Sixteen sheets are now surveyed on this scale. The published sheets are all of the same size—about the size of an ordinary newspaper page. Four sheets in Northern California are of the preliminary class ; they were made for a certain purpose, and now they have served that purpose, and it will be covered with the inch to two-mile work.

Work on this scale has extended over a great portion of the gold belt, and will be extended over all. The purpose is to survey all the gold belt of the Sierras. There will be nearly thirty sheets in all. The survey has no plan at present to extend this work over the desert area or over the valley area. Mr. Grunsky asked me to indicate something of the history of this movement, as I understand it. It is a matter in which I am very deeply interested."

MR. MOLERA.—" In the first place I would like to know what is the distance of the planes of curves in the map — every ten feet or every three feet?"

MR. GRUNSKY.—" I will request Mr. Johnson to kindly give an explanation of the proposed map construction. We have prepared specifications for the map work, which I will read later on. I think this explanation would be very instructive."

MR. JOHNSON.—"On the proposed map the contours will vary on different sheets and on the same sheet. The standard contour might be said to be five feet at the vertical interval. The theory is that the five-foot contours will be carried so far as they can be. Where the grades are such that the lines crowd closely together, the curves can be changed to twenty-five — that is, the five-foot lines drop out. Our present plan is to take five feet as the minimum

interval and where the contours close together, they drop out for twenty-five and fifty, and those drop out for one hundred. Where there are three lines between every pair of heavy hundred-foot contours, we know that the several lines are at twenty-five-foot intervals, and where we see one only, we know it is a fifty-foot contour. You might say we overshade too heavily the plain areas and lower the heights of the mountains by dropping out curves. But the effect and relative proportion is preserved by crowding together the heavier contours, and as they approach, the other contours drop out, and the precision of the work is not sacrificed.

In field work where the grades are very severe and there are a large number of natural points, we put in contours by the indirect method. The jutting points and the long slopes are located. But the contours are not run out — they are put in indirectly from salient points.

When we get down on the plains, where salients disappear, it is the proposition here in California to follow those contours out by leveling; not so much because it will produce a better map, but it will be more economical to do so. As we work off from the valley to the foothill slopes the five-foot contours will disappear, and it is presumed the steeper grades will afford salients for the indirect method. The cost of putting in curves by leveling increases so rapidly where the grades are steep, that it might be a hundred times more expensive to run them out. It has been said to me that it was not worth while to make a map unless it is an actual representation. Now while it is practicable to make a contour map on the scale of an inch to two miles, to make an absolutely perfect map with no visible error, would cost a thousand times as much; it might cost instead of four or five thousand dollars for an atlas sheet, a million dollars to run out all the contour lines. My theory is that by the location of salients; where grades change, to get the summit points, the lowest point and every intermediate point, regardless of the scale of the map; if the locations are so many to the square inch on the paper, the map may be made practically precise.

There is at present work of this kind going on in the South and East of us, where in hill work the contours are put in by the indirect method, and I will venture to assert to you positively, that if every one were run out in levels and platted, the map would show no appreciable difference. I use the plane-table method for this work, and it is to be used for the proposed survey. There are no

field notes that appear on the plane-table sheet. The processes are three: triangulation, leveling, and plane-table."

MR. MOLERA.—"What is the estimate of cost per square mile?"

MR. JOHNSON.—"It varies with the grade. In the work we are speaking of it will vary from six dollars a square mile to sixteen and twenty dollars in a hilly country, on the scale of an inch to the mile. If the publication scale is two inches to the mile, the cost increases very greatly. It might be said, when a survey is made, it would not make any difference what the scale of publication is. That is not true. A map is, after all, merely a collection of points with a sketch in between; it cannot be anything else. The survey of an area means the survey of an infinite number of points, and a map of an infinite number of points, of which we can actually locate only a certain number, that number which we need to locate in order to get the map practically precise, varies with the scale, and the cost per square inch remaining the same, the cost per square mile varies almost with the scale."

MR. MOLERA.—"How many square miles in California do you propose to survey?"

MR. JOHNSON.—"Forty thousand. I think the square mile area of California is one hundred and fifty-six thousand. The Geological Survey has been surveying here for eight years, and it has covered about one fifth of the State, on the scale of an inch to two miles. It will continue until it covers most of the Sierras, and a portion of the coast ranges. It has no plan further than that. It is proposed to survey the more habitable areas of the State. The area proposed for the larger scale does not overlap, excepting some very small areas that will be surveyed by the Geological Survey."

MR. WAGONER.—"Please to state in a general way what that area is?"

MR. JOHNSON.—"It is the Sacramento and San Joaquin Valleys, and smaller valleys between the Coast ranges, and the valleys about Los Angeles and San Diego.

When I spoke to you last April, I spoke of surveying only the great valley of California, but very soon it was pointed out that the survey should extend to important valleys about Los Angeles, and, by this Committee, the area has been extended provisionally to include a fringe of the foot hills and a considerable portion of the Coast ranges. So that would make the area about forty thousand square miles. The total cost will probably be about half a million. The cost will vary from six to eight to sixteen and twenty dollars per square mile."

MR. BROWNE.—"Is it not a fact, Mr. Johnson, that unusual skill would be required in order to reduce the cost to so low a figure as that?"

MR. JOHNSON.—"The topographical map of the United States is a novelty, and even engineers of wide experience do not know what is meant by the modern topographical map. The cost of making that kind of a map may be almost anything that you choose to make it. The Geological Survey has done much work by all sorts of methods to make good maps, and failed. Finally it adopted the Coast Survey methods, and it has branched out, and bettered and improved, until it has found that in no way can a map be made so cheaply as by the plane-table experts of the Geological Survey. I might demonstrate that to you, but not here. I could take you into the field, and ask you to look through the instruments and study how you can better the map, and I challenge you to improve the map in any particular. I have been trying to get critical men to go into the field with me for this purpose. I have been trying to do it myself, but am unable to see any chance to improve.

In the high hills, where I have rod-men going through brush higher than their heads, I can't make it cost more than about $30 a square mile on the scale I am using. If I increase the scale I increase the cost very noticeably. My standard for the topographer is to make his plane-table sheet so full of locations that he couldn't make it any better, make the locations so close together that it cuts the paper all up with them, so that holding a bright light behind it, it seems covered all over with locations, and every location is discernable with the width of the finest needle hole. That work is precise. I think this method is not exceeded anywhere in the world. It has been a matter of evolution for years. The best answer to the question is to go into the field and see it. I could not make it more expensive without throwing away money without results. I am very positive of what I say. I would feel very much mortified if it cost more than I state. I feel very confident, after a long experience, that it would not cost more than the figures I have given. I don't think I could make it cost more than eight dollars on the level portion of the valleys, the five-foot contours would be far apart, and could be made very readily and quickly. It is not only easy, but with our method we can make it so there will be no errors anywhere.

The Geological Survey has done some very poor work, and it has hurt our survey; even the Coast Survey has some flaws. We have,

here and there and everywhere, some work that would stand the severest criticism, and this is a piece that I am doing here. I am trying to make it so that one hundred years, or five hundred years from now there could be no change made upon it anywhere."

QUESTION.—"To what scale are the plane-table sheets made?"

MR. JOHNSON.—"In some maps when the field work is turned over to the engraver he has to reduce it greatly, and he generalizes it out. If an ignorant man is instructed to use his judgment to generalize out, he would ruin the map in such work as this. We instruct the topographers to consider the reduction, and not to leave it to the engraver. The publication should be exactly the same as the field sheet, but the engraver can draw the lines a little bit finer than can be drawn by hand. When the publication scale is one inch to the mile, the field notes would be on one and one fourth miles, or one and one third miles to the inch. The best way to look at a map is to consider that it shall have a certain number of locations per square inch, according to the character of the country.

I think that this proposition would be received with more respect if we said, instead of fifty thousand dollars, it would cost five hundred thousand dollars. Of course at the latter price the survey would not be made, but you would think what a fine survey it would be. I don't think I could make it any better for five hundred thousand dollars than we can for fifty thousand dollars a year. In connection with this work we would survey township corners and section corners, and put up permanent marks to indicate them, using cut stones. These corners would be located, of course, by triangulation, wherever they could be, and they all would be located on the map."

QUESTION.—"Does this estimate of the cost include the office work as well as field work?"

MR. JOHNSON.—"It includes both the field work and the office work until the maps are ready to hand to the engraver. It does not include the cost of engraving."

MR. BROWNE.—"As I was not here when the matter was presented before, I would ask what was the particular reason of bringing it before the Society — what was the special idea? I suppose you could answer that."

MR. JOHNSON.—"I will do so very frankly. I came to California about a year ago, and I was sent here to conduct the work in the mountains; not long before I had been in Massachusetts, where I conducted the larger part of the survey. I like that

larger scale work, and I hope to do it again, and do it better. It seemed to me shortly after my arrival that there was a fine opportunity for doing the same thing here, if the State could be interested in it, and I suggested it to two or three of the professors of the State University; they took hold of the plan with interest, and it was mentioned to some members of the Technical Society. I was requested to make a statement in regard to it, and explain the project, and I did so. Now, my interest in this is considerable; I would like very much to see the work done, because I would have it to do. It would increase the importance of the work of my own section of the Geological Survey.

Since the original suggestion was made, the Faculty of the State University, and the Palo Alto Faculty had a banquet, which I attended, and I there spoke about this project. Since then I have tried to act with propriety on the subject, until it was worked up."

MR. BROWNE.—"What was the object of laying the matter before the Society — was it for an indorsement of the proposition?"

MR. JOHNSON.—"I thought I answered your question. I don't remember that I asked anything at all, or anyone else did, on that occasion. I presented the matter because I hoped that members of the Technical Society would recognize that the proposition was a good one, and take an interest in it. As I remember, it resulted in a vote of endorsement practically by the Society. I certainly did not ask for any such myself."

MR. WAGONER.—"I can answer the question of Mr. Browne. It was referred to a committee. The committee has made a report, and I will call for it."

MR. BROWNE.—"What was the question before the committee?"

MR. WAGONER.—"I was not present, but I think the general subject was referred to a committee. The report, when read, will contain the information desired by you. Therefore I will call for the report."

(Mr. Grunsky, Chairman, then read the report of the committee, which will be found in full in the minutes of the meeting.)

MR. MOLERA.—"Was that committee appointed to represent the Society, with full powers to act for the Society, or simply a committee that would confer with other committees, and then report back the actions of that committee, for the endorsement of this Society?"

MR. GRUNSKY.—"In explanation of that, I would like to state my conception of the matter. We acted as a committee without in

any way compromising or binding the Society; we simply acted according to our own personal views, and we have now referred the matter back to the Society for such action as it may deem advisable. It is, as I understand it, before the Society."

Mr. Browne then moved that the report be received and placed on file, which was carried.

Mr. Browne.—"In order to bring forward some discussion of this matter, I am desirous of introducing a resolution as follows:

Whereas, This Society recognizes the importance of a good contour map of the arable lands of the State, based upon accurate survey, as described by Mr. Johnson, and whereas, this Society does not feel justified in giving the proposition, as indicated, its unqualified indorsement without the opportunity of considering it in its ultimate form,

Therefore, Be it resolved that this Society defer final action until a bill prepared for legislative enactment is available for inspection.

I offer this resolution for the reason that it seems to me we are fully qualified to endorse the proposition that Mr. Johnson makes, in so far as it concerns the making of an accurate map, but I, for one, do not feel able to say, from my own knowledge, that a map can be made at the cost indicated. I have no reason whatsoever for questioning Mr. Johnson's figures; at the same time these figures strike me as being exceedingly small from the experience I have had, which has not been precisely in this line, but on the larger scale maps. But the figures are so surprisingly small that I would not feel confident that they could be prepared at this cost. Furthermore, as Mr. Johnson is not fully or entirely responsible in the matter, we ought to see, before we are brought to the proposition, what shape it takes when it comes before the Legislature. I think that the thing ought to be pretty well surrounded with qualifications to insure accuracy. I have often heard it stated, and I presume from what Mr. Johnson says, he himself fully acknowledges, that a considerable portion of the work of the U. S. Geological Survey has not been characterized for accuracy. Now, I think there ought to be more assurance given in some way that the average of this work will be certainly accurate enough to justify the State in going to that amount of expense. If the work was sure to be in the charge of Mr. Johnson, I, for one, would feel confident of that result; but we do not know that it will be; it may be in the hands of some one else. I am afraid this contemplated Commission will have very little power; I do not think it will be

able to dictate the policy at all, or have anything to do with the appointment of the assistants, and their appointment is a very important thing. It seems to me, from Mr. Johnson's statements and from his knowledge of the whole subject, that he has made a special study of it, and that he is basing his estimates upon his own skilled work; I doubt very much whether a whole corps of assistants will be employed at cheap rates to do this work, and do it in the same way that Mr. Johnson can do it, and as he has shown to this committee, which has spoken of it so favorably.

For all of these reasons it seems to me it would be wiser for the Society to express only an opinion, to the effect that they believe that a map, such as is described by Mr. Johnson, would be of great value, but that they would prefer to look over a bill properly prepared for legislative enactment before giving their full endorsement to the whole scheme. We ought to have something definite to act upon. In other words, to endorse a scheme, and then afterwards to find that it is going to be drafted in an entirely different shape, would not be right or just to the Technical Society. We ought to have something more than a mere statement to endorse. We do not want to be responsible for alterations in a bill that may subsequently be made. That is my reason for making the motion I have."

Mr. Johnson having been asked the cost of these surveys per square mile in other states, as far as he knew, replied as follows:

MR. JOHNSON.—"In Massachusetts, I believe it ranged from eight to fifteen dollars a mile. I think that it was found that the accuracy varied in different maps, according to the scale. At first the men had not so much experience, but now, with a longer experience in the work, they are able to get out very accurate maps at a very slight cost.

In the State of Ohio, it being a very flat country, I think the cost was from five to seven dollars per square mile. Illinois was about the same, and the accuracy was all that could be desired.

Now in the Boston Society of Engineers there have been strong words of commendation for the map and work done there, and all were surprised at the accuracy done at such small cost. I believe that in the State of New York they want this survey now. We desire ultimately to extend the survey across as many States as will be willing to stand the expense."

MR. BROWNE.—"When this question comes before the Legislature very likely it will ask: 'How are we to know that this work

will only cost that much?' And it may be said, here is a body of engineers, the only Society in the State that is competent to pass upon that question, they have endorsed this scheme. The effect might be, perhaps, what it ought not to be. I certainly would not hold, from my knowledge of the subject, that work could be done accurately at such a cost. For that reason I would not feel inclined to endorse a thing in such a shape, as it would be construed that I had made that decision."

MR. MOLERA.—"It seems to me that the map could be made for the amount that Mr. Johnson has stated, but I think it is too cheap. I think a map to be useful should be made on a larger scale. I have copied one of the topographical maps of the Coast Survey, and I know what it is. In my opinion the proposed scale is not large enough for good practical use. I think such a map as Mr. Johnson describes would be very accurate as far as the scale goes, but the scale does not go far enough. I know when I was in the Light-house Department, I tried to get the range the lighthouse covered from such a map, but could not use it.

Another difficulty I see is this: This map would take a great many years to be finished, it would be supported by the contributions of the State, which part of the State is going to have the preference? Those parts to be surveyed last might seriously object: So, taking into consideration all these points, I think our Society should not commit itself by endorsing the making of this map. I think this map will be very valuable and very good, but it would have a great many objections, as I have pointed out.

Again only one part of the State is intended to be surveyed and mapped; and, yet, all the State would be taxed for the making of such map, a very unjust proceeding in my opinion."

MR. BUSH.—"The financial part of the proposition might be arranged this way, that the counties represented on that map be taxed for the map.

Now, as to the use of that map. To my mind it will be useful, and the scale is sufficient. If engineers use it, it will be in the nature of a reconnaissance, as a basis of location. I would think it large enough for that purpose.

But there is another question, and I think Mr. Johnson could answer it. It will remove some of Mr. Browne's objections and that is concerning the nature of his work as a specialist. He must have been a successful teacher to have grouped around him his corps of assistants. Now, if this contour work is to go on at

the same time that the general geological work goes on, where can Mr. Johnson get assistants that he can trust?

The second question is: If he has to teach them, will he have time enough to teach new men?

The third question is: How long will it take him to teach these new men?

The fourth question is: How much wages will have to be paid them?"

MR. JOHNSON.—"I should like to answer some of the questions. As to how many men are available, that is not a serious question. The Geological Survey expends, in this State, twelve thousand dollars a year, that means not very much work. I have with me not a very large corps. I have not been in this State very long, but I have worked in a number of States. I have trained a good many men in various places, and I hope to train some here, and also bring some from the East. It is an easy matter to train new men. That is a dangerous statement to make, and I rather hate to make it. But I very much prefer to take a new man of reasonable intelligence recently graduated from the universities, or perhaps before he has graduated, so that he does not think he knows it all, than a person who is already a professional surveyor. I could not do anything with a professional surveyor for a year, while a new man of reasonable intelligence I could train in a short time. It does not take a man of that kind more than two weeks before he can understand the principles and be of some service. It takes a good deal more than two weeks before he can make an accurate map. I have with me quite a number of expert plane-tablers; I don't think their equal can be found in the world, and they have all been men without previous experience in surveying. They have nothing to unlearn. I don't mean they are all-around surveyors, or experts in leveling, but they thoroughly understand plane-tabling. It is a peculiar kind of work, but it calls for very little else than general intelligence to begin with.

The principles of plane-table work are very simple, indeed, but it requires absolute accuracy. As soon as the first principles are taught, the beginner goes out as a station assistant to a plane-table man, and after a while I go around and talk to him and give him a plane-table, and very soon he is able to run the plane-table as well as the plane-tabler he was working with. In the course of a season a man trained in that way, by watching an expert, and having to assist him, may get to be a good plane-tabler himself, and do excellent work.

At the end of the first year, by using four or five plane-tablers at the very outset, I could easily promise half a dozen atlas sheets. One of those plane-table sheets could be made in from one to four or nine months, according to the character of the surface. At the end of that year I would have half a dozen new men, who would, in the mean time, have become good operators. It would be very hard to convince anyone, who had not seen it going on, that a man can be trained so quickly and so easily, but I speak from experience and know what can be done. An error in the work is very soon discovered, as it will check upon itself. It requires absolute precision, and a mistake will soon show itself. A mistake can never be carried for more than a day, and that is the end of it, there is no possibility of undiscovered error.

Referring now to the Legislature, how are we going to get a bill passed if somebody does not endorse it? If the Technical Society, or any other similar organization, does not approve the scheme, or declines to approve, it practically kills it, and the only thing that stands in the way — granted the desirability of the work — is: How do we know that this work is going to be up to the standard that is claimed for it? How can it be demonstrated to the Technical Society that it will be?

I have done a great deal of this work, and have taken men in the field to examine it. I don't think there is anything on the Pacific Coast that would approach it in standard and accuracy on the same scale. All you have to do is to examine it and demonstrate it for yourselves. It is done now, and by men that I pay $60, $75, and $100 per month. There is one man in charge of a party whose work I do not know how to improve myself.

The only way that the Technical Society can inform itself is to appoint a committee and investigate the work; that has already been done, and the work has been seen by the committee. I am only sorry that they have not seen more of it. Whether the project is approved or not, I should like to say that this work that I have done here is thoroughly good, and can be done again for the same amount of money."

MR. MANSON.—"I do not think the question is one that involves the discussion of the merits of plane-table work or map making. I believe that everybody recognizes that plane-tabling is par excellence the method for map making. I have used it on much larger scale maps. What we ought to take into consideration is, first of all, are we going to recommend the Legislature of the State of

California to appropriate a sum of money which shall be expended jointly with the United States? The question arises, is the United States going to continue these appropriations for the Geological Survey long enough to carry out the work in this State? We are not able to decide that question, and we are not able to get any advice that will give us a reasonable opinion or a reasonable guess as to what the Government is going to do. We know that Major Powell's work, (whether justly or not,) was severely criticized in Washington. Also in certain states and territories, and that fault finding has come from the mining states and territories, where that work has been done. In some of the Eastern States that have been mentioned, the work has met with very satisfactory and agreeable criticism.

The next question is, whether you can induce a California Legislature, in the face of the former Geological Survey work conducted in this State, which ended in a very dissatisfactory manner, to take hold of the matter? The question for this Society to bring before the Legislature will not be its desirability and its usefulness, but it will be whether we can get them to appropriate money to do it? There is going to be the key to the whole proposition."

MR. JOHNSON.—"I think I might say one thing more with propriety on the point that Mr. Manson first brought out, as to whether the work will be continued. Of course no one can say whether the Geological Survey will continue to receive appropriations, or whether the State will continue to make them. As I said at first, it is not an appropriation toward one great result to be attained ten years from now. These maps are prepared in the form of atlas sheets, and everyone is a complete thing in itself, and so much as is done is done for good, and is so much finished. So, if we get an appropriation for a couple of years, and then the whole thing is stopped, we shall have so much work done anyway."

MR. GRUNSKY.—"To me it appears desirable that if this Society wishes to endorse the project, that there should be such an expression at the present time that it may be an influence upon persons in this State who are less qualified than the Technical Society is to pass upon the proposition. If the Society does not wish to render that endorsement, under the present form of the proposition, it is not necessarily withholding its endorsement of the bill to be formulated, — as I presume there will be one — bringing the matter before the Legislature. It will then be known just what restrictions are put

upon the map work, and its control by the State, and the project will appear in a more definite form. This, as I understand, is Mr. Browne's view of the situation. The matter of formulating a bill was discussed by the joint committee. The general outlines of that bill are contained in the specifications, drawn with the object of having them incorporated into the bill. What additional safeguards the Legislature may throw about the work I cannot anticipate."

MR. MANSON.—"Referring to Mr. Browne's resolution I would suggest as a substitute: That the committee now having charge of this matter from the Technical Society be continued as a committee from this Society, as a part of the general committee from the other bodies that are mentioned, with authority to recommend a bill embodying the specifications that have been presented and are on file, to the Legislature, covering this matter; that its action carry with it the endorsement of this Society so far as it is recommended in the report now on file. That it does not carry with it the endorsement of any modifications that any Legislative body or committee may make. I think the Society should be guarded from endorsing a bill which the Legislature modifies after presentation to them."

MR. FEUSIER.—"As there is some doubt in the mind of Mr. Browne, and among many others, as to this work being done for the price stated, I would suggest that the Society appoint a committee to find out whether the work can be done at that cost. As long as there is a latent doubt in the minds of the members, they will never be satisfied about it, and the only way to have the thing fully settled is to find out in some way whether the work can be done at that cost or not."

MR. WAGONER.—"I see no reason why the same committee cannot be instructed to investigate that point."

MR. VISCHER.—"I suggest that these gentlemen also be empowered to select other members to work in conjunction with them. It may be possible that some members would have the time to go into this subject."

Mr. Manson's amendment was subsequently carried in lieu of the resolution offered by Mr. Ross E. Browne, who accepted it as a substitute.

This closed the discussion.

REGULAR MEETING, DECEMBER 2nd, 1892.

PROCEEDINGS.

MINUTES.

The meeting was called to order by the Vice-President, Luther Wagoner.

The minutes of the last regular meeting were read and approved.

The following new members, having been balloted for, were declared elected :

Wm. F. C. Hasson, Consulting Engineer.
Frank E. Lesourd, Mechanical Engineer.
Albert W. Smith, Professor of Mechanical Engineering.
Chas. B. Wing, Professor of Civil Engineering.

The following names were proposed for membership, and referred to the Executive Committee :

For Members :

Augustus Knudsen, Civil Engineer, San Francisco; proposed by E. McCullough, J. C. Sala and Wm. C. Alberger.

Hermann Barth, Architect, San Francisco; proposed by Adolph Lietz, E. T. Schild and Otto von Geldern.

Jos. Lees Maude, Civil Engineer, Riverside, Cal.; proposed by Geo. W. Sherwood, Edward Lownes and P. J. Flynn.

For Junior :

E. K. Hopkins, Hydraulic Engineer, Ross Valley, Cal.; proposed by Luther Wagoner, Geo. F. Schild and H. C. Behr.

A petition having been read by Mr. Manson, for which signatures were requested, praying Congress for the establishment of a Bureau of Roads, and in connection therewith of a school for training young men in the scientific and practical knowledge of road making, a discussion was opened on this subject, which was carried on by a number of members present. This is given in detail in the Transactions of the Society.

Mr. Molera having moved that the Technical Society take no action in regard to the communication, Mr. Manson suggested, as an amendment, that the Secretary notify the sender of the petition that

this Society does not approve of the Government establishing a Bureau of Roads, and that he state distinctly that while in favor of road improvement, it is thought that it should be done through the State and county authorities, and that the information in regard to the proper method of building roads should be disseminated through the agricultural colleges and universities of the various states.

The motion, as amended, was put by the Chair and carried.

The subject of surveying the State of California, and publishing a suitable map, as discussed by the Society at the April meeting, was brought up, a report of the committee, appointed to act jointly with similar committees from other societies, being in order. The committee, appointed April 1st, consists of Messrs. Grunsky, Vischer and Curtis ; before the report of these gentlemen was taken up, a discussion was opened on the subject, participated in by a number of interested members, who stated their individual views as to the necessity of a State map, and its usefulness if made on the scale suggested by the topographer of the U. S. Geological Survey, Mr. Willard D. Johnson. This discussion is contained fully in the Transactions of the meeting.

Mr. Johnson having made certain statements and explanations of the details of the proposed State survey, and a general expression of opinion having been given, the report of the committee was called for, which was read as follows :

Technical Society of the Pacific Coast:

MR. PRESIDENT — Your committee, appointed to act as a conference committee, in conjunction with like committees from other scientific organizations, and from the principal universities of the State, to consider Mr. Willard D. Johnson's proposition of securing State aid for the construction of a large map of the arable lands of California, beg leave to report that the joint committee has held repeated meetings, at which it was agreed that the construction of a good map of the valley areas was desirable, and that it would be of unquestioned advantage to this State to endorse the acceptance of the proposition by the director of the U. S. Geological Survey, according to which, on the basis of specifications prepared by the joint committee, he agrees to direct and conduct the work, subject to approval by a State commission, his department bearing one half of the full expense thereof.

The joint committee was composed of representatives of the following institutions and organizations, University of California, Leland Stanford Jr. University, Technical Society of the Pacific Coast, Academy of Sciences, Science Association of the University of California.

The specifications adopted for the proposed map work, are as follows:

I. That it be a complete contour topographic map, constructed by plane-table survey, based upon triangulation and leveling, showing in addition to the natural features:

(1) The location of all township and land grant corners wherever monuments of the same are in existence.

(2) All railways, canals, and public distributing ditches.

(3) All public roads, and roads which are virtually public by being in unrestricted use.

(4) All county boundary lines.

(5) All cities, towns, villages, hamlets, mines and important places, together with dwellings and public buildings which are outside of town limits, in such a way as to render the map practically useful.

(6) Within every township at least one permanent bench mark indicating the precise altitude.

II. That all contours be on a scheme involving intervals of five feet or multiples of five feet, according to the slope of the ground, and that wherever the slope is less than fifteen feet per mile the contour interval be five feet, and be determined by actual leveling of the contour lines.

III. That all navigable streams and important water-courses be located from actual surveys.

IV. That salt marsh-land and fresh-water swamp-land and overflowed lands be distinguished by two distinct conventions, and be located without reference to the legal segregation lines.

V. That the field scale of the map be not less than one and one third inches to the mile, and that there be at least three triangulation points for each plane-table sheet.

VI. That the publication scale be 1-62,500 (or one mile to the inch, as may hereafter be agreed upon).

VII. That the size of the atlas sheets be determined by the even fifteen-minute lines of latitude and longitude.

VIII. That the United States Coast and Geodetic Survey be requested to furnish as many triangulation points as possible for the proposed survey.

IX. That headquarters for the survey work shall be in California.

X. That the work shall be carried on under the supervision of a commission of five persons representing the State of California, of which persons four shall be appointed by the Governor of the State

— one on the nomination of the State University ; one on the nomination of the Leland Stanford Jr. University ; one representing the mining interests of the State ; one representing the valley interests ; and the fifth commissioner to be selected by the others so appointed.

XI. That the expense of the survey be equally divided between the State and Federal authorities.

XII. That the United States Geological Survey engrave the topographical maps on copper, and that the State of California shall have the privilege of obtaining transfers or electrotypes of each sheet for its own use.

Your committee has been requested by the joint committee to explain the action had in joint conference, and to request a final consideration of Mr. Johnson's proposition.

We desire to state in conclusion, that it has been distinctly represented to us that the State's interests in this matter are to be fully guarded, and that defective work discovered by the State commission shall at once terminate the coöperation.

C. E. GRUNSKY } *Map*
HUBERT VISCHER } *Committee.*

San Francisco, Dec. 2d, 1892.

Mr. Browne then moved that the report be received and placed on file, which was carried, whereupon he offered the following resolution :

Whereas, this Society recognizes the importance of a good contour map of the arable lands of the State, based upon accurate survey, as described by Mr. Johnson, and

Whereas, this Society does not feel justified in giving the proposition, as indicated, its unqualified endorsement without the opportunity of considering it in its ultimate form :

Therefore, be it resolved, that this Society defer final action until a bill prepared for legislative enactment is available for inspection.

After discussing the resolution, Mr. Manson offered the following amendment, which Mr. Browne accepted as a substitute for his original motion :

That the committee now having charge of this matter from the Technical Society be continued, as a part of the general committee from the other bodies that are mentioned, with authority to recommend a bill embodying the specifications that have been presented and are on file, to the Legislature, covering this matter ; that its action carry with it the endorsement of this Society so far as it is recommended in the report, but that it does not carry with it the endorsement of any modifications that any legislative body or committee may make. The Society should be guarded from endorsing a bill which the Legislature modifies after presentation.

The Chair having instructed the committee to investigate the cost of the survey at the price stated per square mile by Mr. Johnson; and having given it the power to select other members of the Society to work in conjunction with the present committee of three, as suggested by Mr. Vischer, Mr. Manson's motion was put by the Chair and carried.

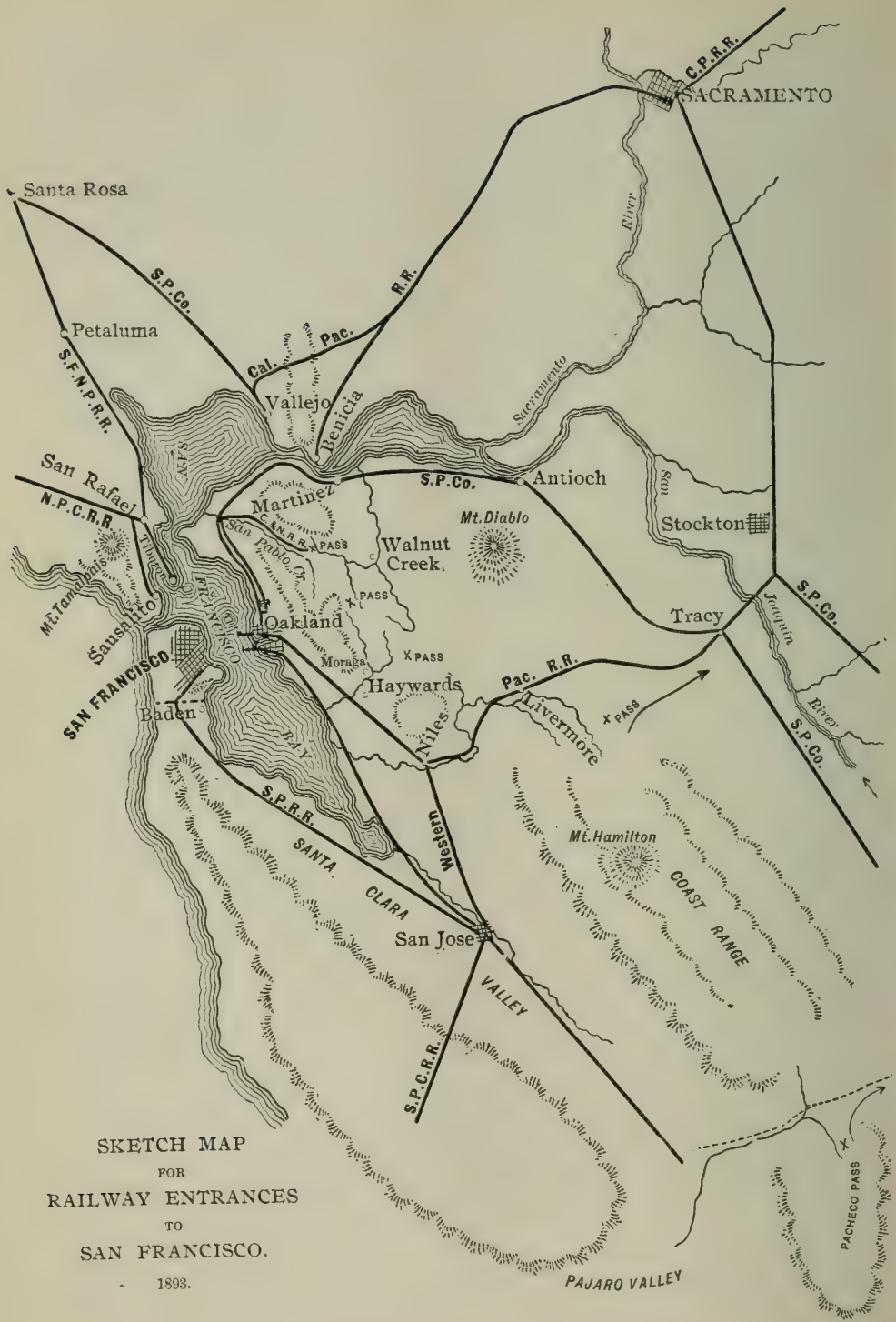
The election of a nominating committee being in order, to select and place before the Society a ticket of candidates for the various offices for the ensuing year, the following nominations were made: Ross E. Browne, Hermann Kower, C. A. Stetefeldt, Horace B. Gale, Adolph Lietz, Frederick Gottfried and Geo. B. Birrell.

After a ballot the following were elected a nominating committee to prepare the ticket: Ross E. Browne, Hermann Kower, C. A. Stetefeldt, Horace B. Gale and Adolph Lietz.

Pamphlets were distributed among the members, containing the results of some interesting tests for tensile strength, etc., of crucible basic, and galvanized basic steel wire ropes, and basic steel wire rods, manufactured by the California Wire Works, of San Francisco. These tests were made at the University of California, in the depart- of mechanical engineering, under the direction of the superintendent of the laboratory, Mr. J. A. Sladky, assisted by Messrs. Kower, Rixford and Raymond.

An aluminum theodolite was exhibited by the firm A. Lietz Co., and the merits of this metal for surveying instruments, noted in a communication to the Society by Mr. Lietz, in which all the details of construction, etc., were given.

Adjourned. OTTO VON GELDERN, *Secretary*.



SKETCH MAP
FOR
RAILWAY ENTRANCES
TO
SAN FRANCISCO.
1893.

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME IX. No. 12.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

RAILWAY ENTRANCES TO SAN FRANCISCO.

By R. E. BUSH, Mem. Tech. Soc.

[Read January 6th, 1892]

The water-front suit, now pending in Oakland, and the recurrence of the rumor of the coming of the Atchison, Topeka & Santa Fé Railway, makes the railway entrances to the City an interesting study.

The discussion this evening will be confined to the matter of grades over the Coast Range, leaving the financial aspect of a right of way and water-front to others.

The peninsula of San Francisco, as a seat of commerce, consists of six basins: two fronting northward, Harbor View and North Beach; and four opening eastward, namely, Mission Bay (including the Market Street region), Islais Creek, Bay View, and Visitacion Valley. These basins are separated from one another by ridges, known respectively as Black Point, Telegraph Hill, the Potrero, Hunters' Point, and Black Mountain.

South of Visitacion Valley, the San Bruno Mountain rises abruptly from the water's edge on the bay, and forms the barrier between San Francisco and the level Santa Clara Valley. The direction of growth of the business city is southward, driven there by the increasing values of Mission Bay lands.

The railroad aspect of the City divides itself into two parts—past and future.

WHAT HAS BEEN DONE.

Two local roads deliver freight on the sea wall, near Telegraph Hill, both from Marin County. The Donahue road (the San Francisco and North Pacific R. R.), operating 162 miles, runs its ferry from Tiburon. The North Pacific Coast R. R., operating 94 miles, runs its ferry from Sausalito. Both roads can avail themselves of the Harbor Commissioners' belt road, when it is completed, along the sea wall.

The Southern Pacific Company delivers its through freight at its Townsend Street station by a transfer ferry from Oakland. This station is also the City terminus of the Coast Division of the Southern Pacific R. R., whose track from San Jose enters the City at the western end of the San Bruno Mountain.

Passenger traffic of the three roads is landed at the foot of Market Street.

THE SOUTHERN PACIFIC COMPANY'S TERMINAL GROUNDS.

Mission Bay basin will always be the commercial center of San Francisco. For this reason all competing roads must secure a good footing therein, either by track or by ferry, so as to have facilities in freight-handling equal to those of the Southern Pacific Company. This Company reaches the center of this basin now, and for future development it owns about 100 acres in the submerged lands of Mission Creek. Sixty acres of this, extending from Channel Street and Third, southward to Butte Street on the Potrero, control nearly one mile of dock space.

This strip was located under the provision of the statute (Laws 1868, p. 720) which granted thirty acres each and a right of way 200 feet wide over tide lands, to the two companies that proposed to parallel the old San Francisco and San Jose R. R. These companies, the Western Pacific R. R. and the Southern Pacific R. R., secured the grant but never built into the City.

In those days the Central Pacific ending at Sacramento, delivered its San Francisco traffic to river steamers and to the California Pacific R. R. running to Vallejo. From its land grants and subsidies, it was the dominant company in railway matters, as the Southern Pacific Company is today. That it might enter San Francisco over its own tracks, it built the Western Pacific R. R. to San Jose and to Oakland, and then purchased the Cohen Ferries from

the City to Oakland and Alameda, all in 1869. One half of the grant in Mission Bay thereby belonged to the Central Pacific Company.

The other 30 acres were owned by the only serious competitor the Central Pacific R. R. ever had, namely the Southern Pacific R. R., which was organized to build east, and thereby secure the Congressional grant on the 32nd parallel.

In December, 1869, the control of the Southern Pacific R. R. passed to Central Pacific men, but its corporate form has been kept intact. In April 1870 the Southern Pacific R. R. paid $3,000,000 for the old San Francisco and San Jose R. R.

Thus the owners of the Central Pacific R. R. secured their terminal grounds in Mission Bay, and also the only track entering the City. By various transfers these all belong to the present dominant corporation — the Southern Pacific Company.

THE PRESENT COURSE OF FREIGHT TRAFFIC.

Since 1870 freight has been ferried across from Oakland rather than make the detour through San Jose to the City. The Company in after years improved upon its Livermore line by building the river line from Tracy to Oakland, via Martinez — encouraging thereby the location of grain warehouses on deep water at Port Costa. It then unified its local lines by connecting its California Pacific track with Port Costa by means of a short spur, and the transfer ferry "Solano." Thus the three systems of the Southern Pacific Company converge at Port Costa — the Shasta line, the Ogden route, and the Sunset route.

So far then in the operations of the Company it has not been necessary to build its Bay Shore line over the 200-foot right of way from Baden to its terminal grants in Mission Bay, nor will it be necessary until by closing the San Luis Obispo gap it has a coast line to Los Angeles.

WHAT CAN BE DONE?

Can other companies get access to the City? Indeed, can one other company get near enough to establish a ferry? Certainly if enough money be spent in purchasing yard room, and a right of way through city property.

In fact into the City new roads must come, for here, not at Antioch, nor at Martinez, nor at Baden, nor in Oakland, but here in San Francisco is the established commercial center of California.

I assume, so far as this paper is concerned, that a new road can enter the interior valley satisfactorily. In fact, crossing of the Sierras, a range whose summit at its nearest point to us lies distant 150 miles easterly from San Francisco — I say, crossing this range is a problem by itself, and must be solved by other considerations, such as the lines of approach to the State, the necessity for snow sheds, the rate of grade required.

I assume then that the road enters and serves the terminal points in the interior, Red Bluff in the north, Sacramento and Stockton in the mid-valley, and Fresno and Bakersfield in the south. How can it reach San Francisco?

ADVISABLE CONDITIONS A ROAD SHOULD MEET.

In planning for a competing road thus situated, I consider the following to be the controlling conditions for freight traffic:

1st. Enter the bay region by grades not exceeding 40 feet per mile.

2d. Locate division yards and shops on cheap lands.

3d. Secure yard room between Market and Townsend Streets, in San Francisco.

4th. Enter San Francisco by a ferry.

PASSES AND GRADES INTO THE BAY REGION.

The bay region comprises:

1st. The Sonoma side, a narrow fringe of valley land on the northern shore, extending from near San Rafael to Vallejo.

2d. The Oakland side, a similar edging extending from Pt. Pinole southward until it opens out at Niles into the Santa Clara Valley.

3d. The Santa Clara Valley itself, the southern arm of the bay region.

This territory is well traversed by railroads, there being nine tracks therein already.

In noting the passes into this San Francisco Bay region I will begin with the southern part — the Santa Fé will probably come in that way; and then take up the northern part—the sale of the Donahue road may introduce an eastern company; and then discuss the more important side whose center is the city of Oakland.

THE SANTA CLARA VALLEY.

The Coast Range is so lofty, and its passes so far south, that the Santa Clara Valley will be entered by those roads only that come into the State south of Yosemite.

Since the San Joaquin Valley offers more inducement to a paralleling road than the Salinas Valley, it is probable that Pacheco Pass, the northernmost one, will probably be chosen by any southern road. Pacheco Pass is a good example of the wisdom of abandoning a wagon road, and searching for a better way in untraveled country. From the forks of the San Felipe Creek the wagon road climbs five miles up a ridge on a five per cent. grade to a handy gap, and avoids the precipitous upper canyons of the South Fork. Near the head of the South Fork, which rises eight or ten miles southward from the wagon pass, the summit ridge is narrow, almost a knife edge compared to the range itself, and was made so by a similar canyon on the east, flowing northward also. By utilizing the low grade of two canyon bottoms, and tunneling a mile or more, it is possible, so I am told, to get through on a grade between 0.8 and 0.9 per cent.

Once through the pass a road would have a level run to Oakland or to Baden. At Baden the San Bruno Mountain is an obstacle. At its east end the shore line already holds the main pipe of the Spring Valley Water Works. In the tide lands off shore is the reserved right of way upon which the Bay Shore line will be built by the Southern Pacific Company. The Bay Shore line once built, a close examination of the crooked and precipitous shore may disclose a feasible line for another company.

The present track at the western end of the mountain has grades of 1.18 going north, and 1.77 going south, over a summit whose elevation is about 400 feet.

THE SONOMA SIDE.

Passing now to the northern part, the two local roads, the Narrow Gauge and the Donahue, possess the two best terminals in Marin County, Sausalito and Tiburon.

Outside of local traffic considerations there are, in this section, two minor impediments for a competing road — the spur that ends precipitously at Carquinez Straits, and the spurs heading in Mount Tamalpais. The first-named spur is now crossed by the California Pacific ten miles north of the river near Suscol. East grades are from 1.3 to 1.7, west grades are 1.75, too high for a trunk road at present. The California Pacific track was built for an opposition trunk road in 1868, but soon was purchased by the Central Pacific. Its

present light traffic does not warrant taking out the high grades. I do not know about other passes in the ridge particularly ; however, the city of Vallejo is now preparing to get its water supply from Green Valley on the other side of the ridge.

Were it not that the War Department occupies Army Point, the eastern end of the straits, through whose grounds the main line of the Southern Pacific now passes on its way to the transfer ferry at Benicia, the north bank of the river might be used for a level line from Suisun to Vallejo, similar to that on the opposite side at Port Costa. The local traffic of Vallejo and Benicia, and the ample space for wharves on the north side, may bring a road there yet. The detour around the spur by the river might discourage San Francisco through travel, and thus make the river line disadvantageous. The longer extent of the cliffs on the south side of the river makes it difficult to arrange for a ferry for a competing road at Vallejo, the narrow space on the south side being occupied now by a double track.

The second impediment consists of the three spurs near San Rafael. These are broad and low, and will introduce into a line much curvature or long tunnels.

The Donahue line approaches its tunnel through the San Rafael hill on grades of 1.9 north, and 1.5 south, through the Corte Madera and Tiburon ridges, it has grades of one per cent. both ways.

The line of the Narrow Gauge crosses these two ridges between Sausalito and San Rafael on grades of 79 feet per mile. The grade on the curve to San Rafael is over 80 feet to the mile.

It is likely that a competing road through the Sonoma side of the bay would buy a trackage right rather than build its own line through the ridges running out from Tamalpais.

OAKLAND.

Of all the bay region, the Oakland side is the more interesting. Here the suburban ferry travel of the City of Oakland gives the Southern Pacific Company one of its chief sources of income. Here also the harbor improvements will accommodate deep-water ships, and the Oakland Water Front Company, a subsidiary company of the Southern Pacific Company, whose title to the whole water front of Oakland is in litigation, has lately offered to sell portions of its tide lands without restriction as to their future use.

The traffic already centering in Oakland can be handled easily by competing roads, for there are no less than three general routes through the Coast Range, back of Oakland, with five passes.

LIVERMORE ROUTE.

The Western Pacific Railroad, from Stockton through Niles Canyon, even in its early day found a one per cent. grade over the Altamont summit, east of Livermore. I cannot give the results of the survey once made through Corral Hollow, south of Altamont. In Niles Canyon the dam and pipe of the Spring Valley Water Works may interfere with a second track. A more direct line from Livermore runs through Crow Canyon to Haywards. If this pass requires a four per cent. grade as said, then Bollinger's canyon may lead to a better pass in the vicinity of Moraga Valley.

WALNUT CREEK ROUTE.

The second route passes to the north of Mt. Diablo, and up the San Ramon Valley to Walnut Creek. From the southerly branch of Walnut Creek there is a pass at an elevation of about 580 feet opening into Moraga Valley. I am informed, though not officially, that the survey for the Great Salt Lake road through this pass is run on a grade of 49 feet per mile between Walnut Creek and East Oakland. There is a 6,000 foot tunnel on their survey through an outlying ridge to avoid a detour to San Leandro. From the westerly branch of Walnut Creek, Charles' Hill Pass leads to the watershed of San Pablo Creek, flowing west.

The California and Nevada Railroad is already in operation from Oakland to Bryants, two miles west from this pass. Their surveys over this summit, whose elevation is about 635 feet, give grades of 1.5 going east, and 1.0 going west. This Walnut Creek route is available for roads coming from the San Joaquin, and also by transfer ferry for those coming down the Sacramento Valley.

CARQUINEZ STRAITS.

The third route is now exclusively occupied by the Southern Pacific Company's double track from Martinez to Oakland. The abrupt hills for six miles or so on the south side of Carquinez Straits give barely room for the present road at the water's edge, and the canyons running back from the river will prevent a trunk line from being laid out at a higher elevation. This river line is the main

entrance of the Southern Pacific Company's system to San Francisco.

Now, not forgetting that the level river line gives the Southern Pacific Company an immense advantage in handling freight traffic, I formulate my first condition for a competing road to be a grade a little less than the reported possibilities of the other passes, namely a grade of 40 feet per mile, or 0.75 per cent. I believe that a more thorough survey will show this grade to be possible without sacrificing first cost.

The second condition, locating division yards and shops on suburban land is self evident from a financial standpoint.

As to the third, securing freight yards between Market Street and Townsend Street, this is the part of the business center whose dock fronts are not controlled by the 60 acres granted and belonging to the Southern Pacific Company. The streets south of Market Street, too, as contrasted with those north of Market Street, are broad, and run almost level for long distances, facilitating truckage.

That roads should enter by ferry is necessary for all roads except those coming in on the peninsula, and even there, from Baden a transfer ferry at present, though slow, would be cheaper in cash outlay than any possible new track entering the city itself.

At some future day a pier bridge from Alameda to Hunters Point, as outlined by Colonel Mendell in 1870, or a cantilever from Goat Island to Telegraph Hill, may carry Oakland trains direct into San Francisco. However, bridging is as improbable as a tunnel under the bay. Ferries will do for years to come.

My conclusion is that there are no engineering difficulties in the way of competing roads.

I wish to acknowledge the courtesies shown me in getting the data concerning grades, by Wm. Hood and Mr. W. G. Curtis, of the Southern Pacific Company; F. K. Zook of the San Francisco and North Pacific Railroad; A. A. Grant of the California and Nevada Railroad; Wm. Graves of the North Pacific Coast Railroad, and W. D. Johnson of the U. S. Geological Survey.

A TOPOGRAPHICAL MAP OF THE STATE OF CALIFORNIA.

[Discussion, Continued from December 2d, 1892.]

MR. MOLERA.—"I understand it is in order to continue the discussion of the subject of the last meeting — the Topographical Survey of this State.

I have with me a collection of prints I would like to show the members, that they can form a practical idea of what is usually done in the way of field work of the topographical surveys, and what is proposed to be done on the map of California upon the scale of one inch to the mile. I think the members will see how difficult it will be to make good field work on such a small scale.

It was stated recently, in a meeting of the Academy of Sciences, that the surveys in England were made on a scale of one inch to the mile. I contradicted this statement. I have looked up the authorities, and now I am sure that my statement is true. In England several maps are made that are intended to represent different parts, for instance, the town maps, which may be on the scale of $\frac{1}{1000}$, or about 30 inches to the mile; then there are what they call the parish maps, which are about ¼ of the scale of the town maps: there is the six-inch map, corresponding nearly to the $\frac{1}{10000}$, which is the scale the United States Survey adopts for the topographical map, and then the publication maps; these are reductions of the six-inch map; it is not the map that is made in the field, but is a reduction map made for publication. These are made all over Europe. I have looked up the records of the topographical maps made in Spain, and I believe they compare favorably with any maps made in the world. They also follow the same scale. The map of Madrid is made upon the scale of one meter to the mile; that is, say, 40 inches to the mile. There, for all the towns and cities which have above 10,000 inhabitants, the scale adopted is $\frac{1}{5000}$, or about a foot to the mile. The smallest maps made in Spain (which contain the whole of the field) are 2½ inches to the mile. I would consider it very unfortunate if this Society endorsed any map that would be less than 2½ inches to the mile, I do not think it would be of any practical value.

I will now read a synopsis of a conference held in Washington, in January, 1892, by the officers of the U. S. Coast Survey, to discuss the particular scale to be adopted for topographical maps."

"A Topographic Conference, composed of officers of the Coast and Geodetic Survey, met in Washington, January and February, 1892, and in discussing the question of scales for field work, the fact was conceded that in field work, other things being equal as to skill, efficiency of personel, instruments, etc., that the scale used was both an index of the measure of accuracy attainable in representing detail, and also an index of the reasonable expenditure required, it being accepted that as the scale diminished the time required to make a given survey was diminished; the cost would therefore be diminished and the degree of accuracy also diminished, until the limit of diminution was reached, when the scale would be represented by a mathematical point, without length or breadth, and then it would cost nothing and be nothing of any practical value, except to show a case of 'reductio absurdum.' It was decided that, for the most accurate and elaborate work, such as that of the District of Columbia, done under the eye of Congress, and in connection with the Engineer Corps of the Army, not less than a four-thousand scale, or 12 inches to the mile, could safely be employed, and the general field work of the Coast and Geodetic survey one ten thousand, or six inches to the mile was requisite.

It was decided that, the field scale should always be larger than the publication scale, and although the publication scale might be properly reduced to show general salient features of detail, the original maps on the larger scale were and should be held for the benefit of the public, and to afford scientific information in regard to limited areas."

"While the publication maps could be published smaller than that by reducing by photography, still the original maps should be held at the disposal of the public. It is supposed that the publication map would give the topography of the country, but it would not be of any practical use.

MR. GRUNSKY.—"I would like to ask Mr. Molera the question as to what the preferred publication scale is of the maps of England?"

MR. MOLERA.—"The publication for the general map of the country is a little over one inch to the mile. It is called the one-inch publication map."

MR. GRUNSKY.—"This is a statement I wanted to have made. I understood Mr. Johnson to say that one inch was the preferred scale."

MR. MOLERA.—"I did not understand it was the preferred scale."

MR. GRUNSKY.— "I did not understand him to state that any field scale was as small as one inch. I think he said the English maps were published by a series of reductions. I simply state this in order to keep the record clear with reference to what Mr. Johnson said in regard to those English maps. I think he is correct."

MR. MOLERA.—"That was the intent of his remarks. I do not think that it is the question at all. If the question is brought before the Society of adopting a field scale, I think that adopted by the English Government should be considered.

Is it possible to do good work on the scale of one inch to the mile? I say it is not. The only reason advocated by Mr. Johnson is that the larger scale would imply a larger expenditure of money. The question, as I understand it, is, what the field work should be in order to make the publication maps?"

MR. FEUSIER.—"I think a map made under the present plane-table method on the scale of one mile, or one and a half miles, can be made as correct as it can be platted. If anyone will take some of the work done on this Coast that was made on a scale of 30 inches or 40 inches to the mile, and reduce it by photography, and put it over that map, he could not find the difference of the width of a line in the whole of the contours."

MR. GRUNSKY.—"With reference to this matter of scale, it is a question of expense and expediency. If our country was thoroughly settled up, and it were necessary to have extremely accurate maps, then we might be justified in making large scale maps, but the expense would be so enormous, that it would be beyond our reach at the present time. The proposition, as now made, gives us a small scale map, one mile to the inch — the field scale a trifle larger than the publication scale. As a committee we have inspected Mr. Johnson's work, we find it is good. If such a result can really be obtained by the plane-table method, it is desirable to have it. That is about what I wish to impress upon our Society. As to accuracy, we shall expect the map to be as promised."

MR. HERRMANN.—"As far as the scale is concerned I am inclined to agree with Mr. Molera. I hold in my hands a circular sent to me by the Secretary, in which I see that the cost of surveying would average about $3,000 for each atlas sheet with contour lines of five feet, that would make $12.50 per square mile. If you will show me the man that can do that I will take off my hat to him. The proposition is impossible. I do not think there is an engineer or surveyor who will say that it can be done within that figure.

A topographical map of California will necessarily cost a great deal of money. Who has to pay the money? The people. How? By taxes. The conclusion is that a map should be a map for the people, not a map for a few scientific gentlemen; not a map for a few railroad companies. What do the people care for the contour lines? Not much. The people care for their property lines; where there is good land and bad land; where there is water; where there is timber and stone; they want to know where the corners are. The circular says that the survey shall show the township and section corners where the monuments are found standing. As most of them are gone the map would not show anything that would be of any utility.

The map, to be of any use to the majority of the people, must be made on a much larger scale. For the valley lands the sheets should be of such a size that they can be used just as the county maps are. As for the hilly land and the bad land, nobody cares for that, for nobody lives upon it. Give the people the benefit of the map, and say beforehand what it will cost, do not say you can do it for $250,000 when it will cost $2,000,000 if carried out as indicated in this circular."

MR. FEUSIER.—"The question of five-foot contours is brought forward, and the gentlemen have in their minds a great mass of contours very close together. I believe the circular states that where the grade is 15 feet to the mile, as in the San Joaquin and parts of Sacramento Valleys, there will be one, two, or at most four contours across the sheet, and not a great mass of contours. These contours can be run out very cheaply.

As to the work being done at so much a square mile, look at the expense of the maps made by the Geological Survey here in California and in Colorado, you would find that the 100-foot contour maps of the mountain regions cost far below that. By our method of making locations we make them very rapidly and at a minimum cost. A map is nothing but a series of sketches at best. Your sketch will necessarily be more accurate if your location points are very far apart.

The present plane-table method is not thoroughly understood, as it is not generally employed by engineers in large work. I know of certain work done in Utah, or the eastern portion of Nevada, I have forgotten which, which was estimated to cost $2,500. The parties hired a man connected with us to do the work, and they said he got a better map for $225 than they could have got for $2,500."

MR. HERRMANN.—"Will you say that the survey of the State can be done on an average of $12.50 per square mile?"

MR. FEUSIER.—"Yes sir."

MR. HERRMANN.—"Making connections with county and section lines—showing these corners?"

MR. FEUSIER.—"About county and section lines I am not prepared to state. I do not think they would cost more than $2 or $3 per square mile."

MR. MOLERA.—"Here is a statement I consider very remarkable. The gentleman next to me has said that if a map is made on the scale of thirty inches to the mile, and is then reduced, that he can make the reduction as well as the reduction can be made by photography. I challenge my friend on the left that if he can draw in the plane table this reduction from six inches to a mile to one and one half inches to a mile, I will take $10,000 and give it to him."

MR. FEUSIER.—"A map made on the scale of a mile to the inch does not necessarily contain all the minute detail of a map made on a scale of 30 inches to the mile—as the ordinance maps of Great Britain; the contours are not run so close together. In a country where it is precipitous, there is nothing but a black mass. I maintain, that if you take a base line by sighting, and draw as fine a line as you can with a chisel-edged pencil, that it is more accurate than you can bring it down by any method of platting. On a small scale you have points given by triangulation to four or five decimal places. That is really absurd, for you cannot plat them within 30 or 40 feet. Now, in this plane-table method we use the finest kind of needle hole, and if, for example, you locate that corner of the room, or the two other corners, your location by sighting is probably more accurate; the intersection of those lines is nearer the true position than if platted by a method of rectangular coördinates. In a map made on a scale of 1⅓ inches to the mile, and reduced one third in publication, making it a mile to the inch, I maintain that the positions are as accurate as if made by the other method.

What is the use of doing a lot of large scale work which will only be for a few, and not for the people? The ordinance maps of Great Britain are used by specialists, not by the people. At present I am engaged on work that I would give a good deal for this topographical map of the country."

MR. MOLERA.—"The gentleman has just said something, that in my opinion is begging the question. He says that in a very small map you can only put in a certain amount of work; if you

attempt to do more it would be a black mass. That is what we have been contending from the beginning; that if we adopted such a small scale we could not represent enough on the map. What do we want with a map that cannot tell us the boundaries of our land, or whether anything is five hundred feet this way or the other? I do not think it is of any practical use. I live in the country, and I have to build canals for irrigation. I have to build country roads. I am in a remote location where we have no county or State aid; everything done is done by ourselves. I know what I am talking about; I know what we want. When the Coast Survey has a map, I want to use it. I know its utility, but if on a larger scale it would be more useful. A topographical map on a small scale is a very good thing by which to get a general idea of the country; it would be useful for projected railways, showing the altitudes of the highest points, and give a general idea as to the best place to survey. But for the people, a map on the scale of a mile to an inch would be absolutely useless. I believe that anybody who has use for such a map will coincide with me. I think that spending half a million dollars for a map that will be a pretty picture at the most, would be just throwing away money. Let us spend two millions, or five millions, if necessary, but let us spend it in something we can make use of, and the generations that follow us."

MR. FEUSIER.—"I agree with the gentleman that we want a large map if we can get it. I do not believe we can get it, for the cost is enormous. Then it resolves itself down to either a very fine map that can be used for all scientific purposes, or nearly all, or no map at all. I think it would be much better to have a map of parts of the State of California — a good map that may be of some use — than no map at all."

MR. RICHARDS.—"I do not think it is the province of this Society to deal with the question as to whether we can get a map from the Legislature. I do not think the question of whether we can get a map that is one inch to the mile, or one that is five or six inches to the mile, is a proper question before this Society, because it cannot be answered or proven. I think a subject that comes before the Society should be capable of some definite demonstration; but those things which have to be decided by popular opinion or by votes, we have nothing to do with. I think our transactions and resolutions should not extend beyond the technical character of the map."

REGULAR MEETING, JANUARY 6th, 1893.

PROCEEDINGS.

MINUTES.

The meeting was called to order at 8:30 P. M., by the President, John Richards.

The minutes of the last regular meeting were read and approved.

The following new members, having been balloted for, were declared elected :

For members :

Augustus Knudsen, Civil Engineer.....San Francisco, Cal.
Hermann Barth, Architect.....San Francisco, Cal.
Joseph Lees Maude, Civil Engineer.....Riverside, Cal.

For Juniors :

E. K. Hopkins, Hydraulic Engineer.....Ross Valley, Cal.

The following names were proposed for membership, and referred to the Executive Committee :

For Members :

George Beardsley, Civil Engineer, Phoenix, Arizona ; proposed by Alex. O. Brodie, Geo. F. Schild and Otto von Geldern.

A. J. Butler, Civil Engineer, Colusa Cal. ; proposed by D. E. Hughes, John Richards and C. E. Grunsky.

Reginald Enoch, Draughtsman, San Francisco, Cal. ; proposed by L. J. Gates, L. A. Corneille and A. E. Chodzko.

Geo. E. Hoyt, Mechanical Engineer, San Francisco, Cal. ; proposed by John Richards, H. C. Behr and A. d'Erlach.

For Associates :

Charles Edward Ertz, Contractor, San Francisco, Cal. ; proposed by E. T. Schild, R. E. Bush and A. Lietz.

John J. Searle, San Francisco, Cal. ; proposed by Luther Wagoner, Hubert Vischer and Otto von Geldern.

Mr. R. E. Bush read a paper entitled, "Railway Entrances to San Francisco," which is held open for discussion at a subsequent meeting.

Mr. Alfred Solano, of Dunkirk, N. Y., in a communication to the Society, calls attention to the subject of night schools connected with the large manufacturing establishments of the United States. He points to the benefit derived from such schools, and to the great importance of the subject from a number of standpoints. He men-

tions that an admirable school of that kind has been established in connection with the Brooks Locomotive Works in Dunkirk, N. Y., at which seventy-nine pupils were in attendance. They had come from the extensive office, and from every other department of the great works. The lessons given include arithmetic, algebra and geometry, with special attention to mechanical drawing. The instruction is free, as is also the use of books, and the supply of drawing material and instruments, and all other apparatus. The attendance is not compulsory, but it is understood when apprentices enter the works that they will attend the school. This school is under the supervision of Mr. Alfred Solano, a member of the Technical Society.

The Secretary was instructed to answer the communication, and to express the thanks of the Society to Mr. Solano for calling attention to the existence of this usetul institution.

The following report of the Nominating Committee was read:

To the Technical Society of the Pacific Coast:

MR. PRESIDENT AND GENTLEMEN: — Your Committee, appointed at the last meeting to present a list of nominations for the officers of the Society for the ensuing year, according to Article II of the By-Laws, beg leave to report the following names of members, who are believed to represent fairly the different branches of the profession, as required by Article XII of the Constitution, and who, in the opinion of the Committee, will, if elected, serve in their respective offices with credit to the Society.

For President, C. E. GRUNSKY.
For Vice-President, CHARLES D. MARX.
For Secretary, OTTO VON GELDERN.
For Treasurer, GEO. F. SCHILD.

For Members of the Board of Directors:
GEO. W. DICKIE.
JOHN HAYS HAMMOND.
FRANK SOULÉ.
LOUIS FALKENAU.
WILLIAM F. C. HASSON.

Respectfully submitted by the Committee:
HORACE B. GALÉ.
ROSS E. BROWNE.
ADOLPH LIETZ.
C. A. STETEFELDT.
H. KOWER.

San Francisco, Jan. 6th, 1893.

The chair appointed H. C. Behr and Hermann Kower judges of election to act during the ballot, in accordance with Section 2, Article II, of the By-Laws.

The subject of the survey of the State of California was brought up, Mr. Molera discussing the advisability of publishing charts on such a scale that they shall become useful for every purpose to which a State map may be put. After reading a synopsis of a conference held in Washington by U. S. Coast Survey officials to consider the proper scale of topographical charts, which was ultimately adopted at $\frac{1}{1000}$, a discussion was opened, which was carried on by Messrs. Grunsky, Hermann, Feusier and Richards. No official action was taken in the matter.

Adjourned. OTTO VON GELDERN, *Secretary.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME X. No. 1.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

NOTE BY THE EDITOR.

The professional paper especially prepared for this number of the Transactions, by Mr. Willard D. Johnson, of the U. S. Geological Survey, has been lost in the mail, and could not be replaced in time for this issue. It will be rewritten, however, by the author, and will appear in the next number in addition to any other professional paper already prepared therefor.

ANNUAL MEETING, JANUARY 20th, 1893.

PROCEEDINGS.

MINUTES.

Called to order by President Richards.

Upon a count of ballots by Messrs. Behr and Vischer, the following Officers and Directors were declared elected unanimously, to serve during the year 1893.

President, C. E. Grunsky. Vice-President, Chas. D. Marx.
Secretary, Otto von Geldern. Treasurer, Geo. F. Schild.

DIRECTORS:

Geo. W. Dickie. John Hays Hammond. Wm. F. C. Hasson.
Louis Falkenau. Frank Soulé.

The Treasurer submitted the following report, which was read:

TREASURER'S REPORT FOR 1892.

To the President and Directors of the Technical Society of the Pacific Coast:

GENTLEMEN:—I have the honor to make the following detailed report of collections and disbursements, assets and liabilities, during my term just ended.

RECEIPTS.

Balance on hand, January 1st, 1892	$ 3 88
Received from members for dues	1,803 50
" for admission fees	165 00
" " use of room	30 00
" " certificates of membership	32 00
" " sale of printed Transactions	10 85
Total	$2,045 23

DISBURSEMENTS AS PER VOUCHERS.

Rent of Rooms	$534 00
Secretary's salary	300 00
Collector's commission	145 00
Discount on checks	2 25
Janitor and Elevator Man	38 00
Office expenses	44 50
Furniture	43 70
Stationery	24 57
Postage and expressage	131 60
Short-hand reporter and type-writer	58 60
Photographer (lantern exhibits)	15 00
Printing	546 95
Engraving	140 25
Book binding	9 10
Advertisements	9 90
Gas	3 00
Total	$2,046 42

ACCOUNTS RECEIVABLE.

Unpaid dues to January 1st, 1893	$572 00
Unpaid admission fees	50 00
For printed Transactions (sold)	35 00
Certificates of membership (sold)	5 00
Room rent due from the Sierra Club	10 00
Total	$672 00

ACCOUNTS PAYABLE.

Geo. Spaulding & Co.	$570 30
Industrial Publishing Co.	208 40
Britton & Rey	135 00
Total	$913 70

SUMMARY.

Accounts Payable	$913 70
Accounts Receivable	672 00
Balance	$241 70
Collections for the year	$2,045 23
Disbursements for the year	2,046 42

GEO. F. SCHILD, *Treasurer.*

Approved by the Finance Committee:

H. C. BEHR,

A. SCHIERHOLZ,

C. E. GRUNSKY.

The Finance Committee here reported that under existing conditions the debt of the Society would be liquidated by August. Thereupon the report of the Treasurer was accepted and filed.

The proposition for membership of Clarence L. Cory was referred for immediate action to the Board of Directors, who passed favorably upon it.

The Secretary submitted the following report, which was ordered received and printed.

REPORT OF THE SECRETARY FOR 1892,

I have the honor to submit to the Society the following report of its condition and progress during the past year:

The present total membership is 236, as follows:

Honorary members	2	Juniors	5
Members	209	Associates	20
			236

Of these 154 are resident, and 82 non-resident. A geographical distribution places in

San Francisco and vicinity	154	New York	5
Other parts of State of California	44	Oregon	4
Arizona	3	Utah	1
Idaho	1	Washington	5
Illinois	2	Africa	2
Massachusetts	2	England	1
Missouri	1	Hawaii	2
Montana	1	Mexico	1
Nevada	5	South America	1
New Mexico	1		236

Professionally divided, there are:

Architects	5	Military Engineers	4
Builders	1	Mining Engineers	27
Chemists	5	Naval Architects	1
Civil Engineers	86	Professors of Universities	9
Draughtsmen	5	Scientists	3
Electrical Engineers	2	Surveyors	12
Instrument Makers	2	Technologists	3
Marine Engineers	2	Topographers	1
Mechanical Engineers	54	Associates of various callings	14
			236

During the year 1892 the Society increased in membership as follows: Admitted, 48; reinstated, 1; total, 49. Of these there are:

Members (1 reinstated)	43	Associates	3
Juniors	3		
			Total 49

Professionally divided:

Architects	2	Professors of Universities	5
Civil Engineers	21	Surveyors	3
Draughtsmen	1	Topographers	1
Mechanical Engineers	11	Associates of various professions	3
Mining Engineers	2		
			Total 49

Membership of Society January, 1892:

Members and Associates.....201 Total membership in 1892.....250
Increase in 1892 49

Loss in 1892:

Deaths..... 2 Supensions..... 6
Resignations..... 6 —
Total 14

Present membership.....236 Gain in 1892..... 35

Deaths during the year:

Andrew Fraser. L. L. Robinson.

Resignations during the year:

Robert Hinchliffe. Wm. Letts Oliver. Alexander Watson.
Howard C. Holmes. Wm. G. Raymond. Frank K. Zook.

Ceased membership during the year:

A. Boschke. John M. Curtis. Wm. Irelan, Jr.
Chalmers Scott. Wm. M. Fitzhugh. Harry I. Willey.

Number of regular meetings held during the past year.....12 Number of papers read and discussed..... 15
Directors meetings. .....12 Number of general discussions.... 5

Papers were published in the printed proceedings of the past year on the following subjects:

Onyx on the Pacific Coast.
The Commerce of San Francisco.
Water Pipes Built of Wooden Staves.
The Sickle or Perfect Railway Curve.
Silver, Its True Place in the Currency.
Circulation of the Atmosphere of Planets.
A Department of Irrigation Needed in our Universities.
A Problem in Launching the Steamer "Peru."
Corliss Engines.
Efficiency of Hydraulic Passenger Elevators.
The General Circulation of the Atmosphere.
Height and Position of Mt. St. Elias.
The Classics *vs.* Natural Sciences at a German Gymnasium.
Climatic Features of the Pacific Coast.
Railway Entrances to San Francisco.

These papers appeared in the regular monthly editions of the Society's bulletin, and were mailed in exchange for many prominent publications of a similar character, both in the United States and abroad. Inquiries for papers are received every day, and have been sent upon application, to numerous addresses.

Contributors during the past year:

Louis Falkenau.
Geo. W. Dickie.
D. C. Henny.
D. E. Hughes.
Willard D. Johnson, U. S. Geological Survey.
J. W. Treadwell.
Marsden Manson.
C. E. Grunsky.
Hugo P. Frear.
J. B. Pitchford.
H. B. Gale.
Lieut. Jno. P. Finley, U. S. A.
M. B. Kerr, U. S. Geological Survey.
C. A. Stetefeldt.
Robert E. Bush.

The following discussions were held on topical questions:

How can we Account for the Fact that Machine Work in San Francisco is, with few Exceptions, not made to Standard Sizes? Opened by John Richards.

What is the Effect of Modern Brakes upon the Railway and its Supporting Structures? Opened by Otto von Geldern.

New Engine Valve Gearing. Opened by J. H. Hoadley.

Government Aid and Control of Roads and Highways. Opened by Mr. Richards.

A Topographical Map of the State of California. Opened W. D. Johnson.

Respectfully submitted,

OTTO VON GELDERN, *Sec'y.*

Mr. C. E. Grunsky, in well-chosen remarks, referred to the work of the Technical Society during the past year, and on behalf of the members, extended the thanks of the Society to Mr. John Richards, the retiring president, for his earnest efforts in promoting the welfare of the organization, and expressed the hope that he would continue to give his coöperation in the work of the future.

Mr. Richards in reply called attention to the proper functions of the Technical Society, and its sphere of usefulness in all technical questions of import on the Pacific Coast, predicting for it a bright and prosperous future.

It was agreed that two permanent tellers be qualified to count the ballots for membership elections at the regular meeting nights of the Society. These ballots are to be opened and counted by these tellers before the meeting is called to order, to avoid an awkward delay in the regular business of the evening.

A discussion was then entered upon as to the proper methods of printing and issuing the monthly Transactions, without taking any official action, however.

Adjourned.

DIRECTORS' MEETING JANUARY 26th, 1893.

Called to order by President Grunsky. All the members were present. Upon motion that the regular committees be appointed by the Chair, Mr. Grunsky made the following selection :

EXECUTIVE COMMITTEE.

Geo. W. Dickie, Chairman. Frank Soulé. W. F. C. Hasson.

FINANCE COMMITTEE.

Louis Falkenau, Chairman. Geo. W. Dickie. Chas. D. Marx.

A sub-committee on "Lectures and Papers" was thereupon appointed in regular form, consisting of the following members :

John Richards. Hubert Vischer. John Hays Hammond.
Ross E. Browne. W. F. C. Hasson.

The President stated that according to the Constitution (Article XII) he was empowered to appoint a substitute in case of the temporary absence of any member of the Board of Directors.

It was then unanimously agreed that the Directors' Meeting be held regularly on the third Friday of each month, in the Society's room, 819 Market Street, at 4 P. M.

Mr. Jos. Lees Maude, (member Tech. Soc.) of Riverside, Cal., appeared before the Board and suggested the formation of a branch of the Technical Society in Los Angeles. His purpose of attending here was to get the necessary information in regard to this matter. The President stated that, in his opinion the Constitution contained nothing to prevent any number of members from forming individual societies in other localities, who would, nevertheless, be identified with the main body here. The name "Technical Society of the Pacific Coast" fully justifies such localization, which could only be of benefit to the Society at large. He suggested that the members forming the local societies pay their non-resident dues here, for which their professional papers would be published in the Transactions of the Society and mailed. That, in addition, they pay certain monthly dues to their local organization, in order to defray the expenditures of rent and other incidentals, through their own financial officials, with whom the parent Society should have nothing to do, as it would be difficult to supervise the individual affairs of local bodies.

Mr. Maude agreed to report this opinion of the Chair to the members in Los Angeles; whereupon he submitted to the Board a Bill entitled: "An Act to Define the Duties of County Surveyors, and to Regulate and Provide for their Compensation," which contained the following clauses:

"SECTION 1. The County Surveyor shall be a resident and elector of the County for which he shall be elected, and shall be a licensed surveyor of the State.

SEC. 2. The County Surveyor shall record all maps filed in the office of the County Recorder of the county for which he shall be elected, and shall be ex-officio Deputy County Recorder of said county for such purposes. He shall plat, trace, blue-print and otherwise make all county, township, road, district, assessors' and all other maps for the county of which he is surveyor. All of such records shall be transcribed, which, with all data obtained by the County Surveyor from private sources, shall be filed in the County Surveyor's office, and the same thereafter shall become the property of the county.

SEC. 3. Each county shall furnish all field and office instruments, and all furniture, office and record books, and other material necessary to be used by the County Surveyor or his deputies.

SEC. 4. The County Surveyor shall prepare all plans and specifications, and make all necessary surveys, and superintend the construction of all county bridges, roads and all other engineering work ordered by the Board of Supervisors. All such plans, maps, specifications, field notes and surveys shall be filed in the office of the County Surveyor, and the same thereafter shall become the property of the county.

SEC. 5. The County Surveyor shall make all surveys and profiles of all county roads and highways within the county in which he shall be elected, and shall file all field notes, and shall plat and record all surveys and profiles in proper books in his office for the use of the county.

SEC. 6. The County Surveyor shall receive ten dollars a day for all work performed, and in addition thereto all expenses and transportation on work performed in the field. He shall be allowed such expert and other assistance as may be necessary to properly conduct the business of his office. All clerks, assistants and deputies shall receive a reasonable compensation for their services, to be fixed by the Board of Supervisors.

SEC. 7. The County Surveyors of the different counties of the State shall constitute a Road and Engineering Bureau of the State. Said Surveyors shall meet on the first Monday after the first day of May of each year at the City of Sacramento, to discuss and plan a uniform system for the regulation of the affairs of their respective offices. Each county shall pay the expenses of transportation for the Surveyor of said county attending such convention.

SEC. 8. All maps and plats that are required by law to be filed with the County Recorder, shall, before the same are recorded, be examined by a board of three examiners, of which the County Surveyor shall be ex-officio chairman, and the County Clerk and County Recorder members. Said board shall correct all inaccuracies or deficiencies in such map or plat, or require same to be corrected by the persons filing the same. No map or plat shall be recorded unless endorsed by the chairman and members of said board, or their deputies.

SEC. 9. All Acts or parts of Acts inconsistent herewith are, for the purposes of this Act, hereby repealed."

After discussing the matter for some time it was moved that Mr. Maude's Bill be referred to the proper committee, and brought up at the next regular meeting of the Society. Carried.

Adjourned.

REGULAR MEETING, FEBRUARY 3d, 1893.

PROCEEDINGS.

MINUTES.

The meeting was called to order at 8:30 P. M. by the President, C. E. Grunsky.

The minutes of the last regular meeting, and of the Annual Meeting, were read and approved.

The following names, having been balloted for, were declared elected:

Members:

A. J. Butler, Civil Engineer.....Colusa, Cal.
Reginald Enoch, Draughtsman.....San Francisco, Cal.
Clarence L. Cory, Instructor.....Berkeley, Cal.
Geo. E. Hoyt, Mechanical Engineer.....San Francisco, Cal.
George Beardsley, Civil Engineer.....Phoenix, Arizona.

Associates:

Charles E. Ertz, Contractor.....San Francisco, Cal.
John J. Searle, Business man.....San Francisco, Cal.

The following names were proposed for membership, and referred to the Executive Committee :

For Member :

Lawrence Thompson, Civil Engineer, San Francisco ; proposed by Hubert Vischer, Luther Wagoner and C. E. Grunsky.

For Associate :

Edmund McNevin, Navigator, San Francisco, Cal, ; proposed by George F. Schild, Otto von Geldern and C. E. Grunsky.

Mr. Willard D. Johnson, of the U. S. Geological Survey, then read a paper, and delivered an interesting address, entitled "Methods and Results with the Plane Table in Topographical Surveying." His discourse was illustrated by a number of diagrams to explain the methods, and by topographical charts, showing the work done in the field by means of the plane table as perfected and simplified by the author.

Mr. Joseph Lees Maude appeared before the Society, and presented a bill entitled : "An Act to Define the Duties of County Surveyors," as published in full in the minutes of the Director's Meeting preceding. Mr. Maude explained to the Society the various reasons why such an Act should be passed by the State Legislature, calling attention to numerous abuses in the present system of county surveys, particularly in regard to public roads and highways, the lamentable condition of which in many localities he described, and finally asked for the support of the Society to carry the measure to the Legislature.

The Bill, as suggested by Mr. Maude, was then discussed at length, Mr. Ernest McCullough submitting a written communication expressing his personal opinion of the proposed measure, clause for clause, as follows :

"If the office of County Surveyor is to continue, there should be some duties defined. The official ought to be a licensed surveyor, and all work connected with the filing and preparing of plats should be in his office. He should examine maps presented for filing, and send them back when omissions are found ; but there should be a law defining what constitutes a map, and I believe that all maps filed, should conform to the requirements exacted in the section relating to that subject in the Licensed Surveyor's Act.

Maps presented by licensed surveyors, in accordance with the law should be exempt from examination by the county surveyor, in order that no abuse of power may occur, as he would practically have in his hands the reputation of every surveyor in the county.

The office is generally sought as an advertisement, and the surveyor should certainly provide his own field and office instruments. The county should furnish office supplies and tapes, rods and chains.

There should be established, by the county surveyor, a true meridian at the county seat and at the principal town in each supervisor district, by astronomical observation, and all surveys made, should have their bearings referred to the nearest meridian. Failure to place on the plat the true variation and date it was ascertained on the meridian, should invalidate the record.

The surveyor should receive ten dollars per day and expenses for surveys etc ; and for examining and recording maps, one hundred dollars per year. If paid ten dollars a day for all work, the official possesses the means of examining one plat each day, and thus make map filing very expensive.

Very few surveyors are engineers, and therefore no law should burden a surveyor with an engineer's duties. In every county there should be an engineer of bridges and roads, and under him salaried assistants, whose whole time should be given to the work. The county surveyor, even if competent, would be away on surveys so often, that it will prove impossible for him to give enough attention to the roads. There is more to be done on roads than to make surveys and maps.

The road laws should provide for county roads built and maintained by the county, at least one in each district, and district roads built with the aid of the county, and maintained by the districts. Every town of over one hundred families should maintain its own streets, and aid in maintaining the roads in its district. It should be unlawful for road money raised outside the town limits to be expended on the town streets. This law would prevent an abuse now too common, of county seats raising the road tax on their own streets and resisting attempts at incorporation, for fear of having to keep up their streets without outside assistance.

Section seven of the proposed Act is enough to defeat the bill, as the legislature will find in it no benefit to the State, but only an opportunity for surveyors to enjoy privileges at the public expense. This is an injury to the profession. If surveyors wish to form a society for their mutual advantage, let them do so, but do not make the public pay for their educational organizations."

Mr. Maude thereupon made the following statement :

" Since Mr. McCullough saw the Bill it has been changed somewhat at my suggestion and that of surveyors.

The first clause in regard to examination of maps presented for record has been so amended, that maps filed by licensed surveyors are specially exempted from examination. The examination of the other maps is not necessarily done by the surveyor himself, it can be done by his deputies who are competent to do so.

The part referring to the county furnishing field instruments has been somewhat amended so to embrace only certain counties. In my county I have three parties in the field ; I have two sets of instruments myself, being more fortunate than some in this regard ; but I don't think the surveyor should be called upon to furnish all the instruments, especially for large counties. It would seem a hardship to furnish assistants with instruments and get $10 a day."

The President then said that there was a point Mr. Maude did not notice, with reference to the qualifications of the surveyor, and the matter of planning roads and bridges. The Bill provides that expert services may be employed for such a purpose, and that, he thought, would fully cover the question raised by Mr. McCullough as to the competency of the surveyor.

Mr. Maude replied that the Bill distinctly states that the surveyor may employ such expert assistance as necessary, that a law of the State requires that all bridges costing over $500 shall be advertised for, and bids submitted according to the advertisements and plans. He said that a surveyor would certainly be allowed to employ some one to examine those plans and oversee the work of construction. He appreciated the fact that an incompetent person may hold such an office, but unless a proper basis be supplied, how would it be possible to obtain efficient men to take hold of it? It must be made respectable before respectable men would be willing to touch it.

The President stated that, as this Society is one that embraces a number of branches of the technical profession, and as only one of those is distinctly and immediately interested in the matter referred to, it seemed rather difficult for this aggregation of professions to express a positive and concise opinion at the present time. It would, of course, be in order for anyone to offer suggestions in that direction, as it is thought that this Society is for the purpose of advancing the interests of the profession as well as for the specific purpose of discussing scientific subjects ; and, therefore, evidently

the subject matter would properly come before it. It was left at the option of the Society as to what action should be taken.

Thereupon Mr. Vischer, after some remarks on the subject, moved :

"That the President be requested to name a committee of three members of the Society to examine into and consider the merits of the Bill now before the Legislature, with authority, if the facts in their judgment warrant it, to express it as the opinion of the Society that a Bill of the nature specified is desirable." Carried.

The Chair thereupon appointed the following : Hubert Vischer, A. H. Sanborn and F. H. Carssow.

This committee proceeded at once to the duty assigned it, and subsequently submitted the following report :

The undersigned, members of the Technical Society of the Pacific Coast. appointed a committee to examine and consider the merits of a Bill as proposed by the county surveyors of the State, to define the duties of county surveyors and to regulate and provide for their compensation, desire herewith to express it as the sense of this Society that the placing of public work, particularly road and bridge construction, under competent technical control and supervision, is desirable, and to this extent endorse any legislative measure having this object in view." [Signed.]

HUBERT VISCHER.
A. H. SANBORN.
F. H. CARSSOW.

Adjourned.

NOTE.

The Act as finally introduced to the Legislature, and referred to its Committee on County Government and Township Organization, stands as follows :

"SECTION 1. The County Surveyor shall be an elector of the county for which he shall be elected, and shall be a licensed land surveyor of the State.

SEC. 2. The County Surveyor shall copy, plat or trace all maps filed for record in the office of the County Recorder of the county for which he shall be elected, and shall be ex-officio Deputy County Recorder for said county for such purposes, *provided, however*, that all maps and plats filed by a licensed land surveyor, and such other maps and plats as are filed and are thereby made a record, are exempt from the provisions of this Act.

SEC. 3. The County Surveyor shall plat, trace, blue-print, or otherwise make all county, township, road, district, assessors, and all other maps for the county of which he is surveyor. All such maps, which shall be platted, traced, blue-printed, or otherwise made

as aforesaid, shall be filed in the County Surveyor's office together with all data obtained by the County Surveyor from other sources, and the same thereafter shall become the property of the county.

SEC. 4. The County Surveyor shall prepare all plans and specifications, and make all necessary surveys, and superintend the construction, repair and maintenance of all county roads, and perform such other engineering work as the Board of Supervisors may direct. All such maps, plans, specifications, field notes, and surveys shall be filed in the office of the County Surveyor, and the same shall thereafter be and remain the property of the county.

SEC. 5. It shall be the duty of the County Surveyor to examine all bridges and work on bridges, where the same shall have been done by contract, before the same shall be accepted, and to report to the Board of Supervisors whether or not said construction and work has been properly performed in accordance with the specifications of such contracts, *and further*, it shall be his duty to advise the Board of Supervisors in all matters of bridge construction, maintenance and repair as may be requested by them.

SEC. 6. The County Surveyor shall make surveys and profiles of all unsurveyed county roads and highways within the county in which he shall be elected, and shall file all field notes, and shall plat and record all such surveys and profiles in proper books in his office, for the use of the county.

SEC. 7. The Board of Supervisors of each county shall provide for the use of the County Surveyor, a suitable office, office furniture, heat, light, and care for the same, office instruments, office and record books, and other necessary material. And in counties of the first to the twenty-second class the Board of Supervisors shall furnish such field instruments as may be necessary for the working of the office.

SEC. 8. In lieu of fees, as now provided by law, the County Surveyor shall receive ten dollars per day for all work performed, and in addition thereto all expenses and transportation on work performed in the field. He shall be allowed such deputies, clerks, and employees as the Board of Supervisors may determine. The deputies of the County Surveyor, as herein provided for, shall receive a sum not to exceed five dollars per day for each day's labor performed, and in addition thereto all expenses and transportation on work performed in the field. The clerks shall receive a sum not to exceed four dollars for each day's labor performed, and all other employees of the County Surveyor shall receive a sum not to exceed the sum of two dollars and fifty cents per day for each day's labor actually performed, and in addition thereto all expenses and transportation on work performed in the field.

SEC. 9. All Acts or parts of Acts inconsistent herewith are, for the purposes of this Act, hereby repealed.

SEC. 10. This Act shall take effect and be in force from and after its passage."

OTTO VON GELDERN, *Sec'y.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME X. No. 2.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

AN EXPERIENCE WITH A 24-INCH GAS MAIN.

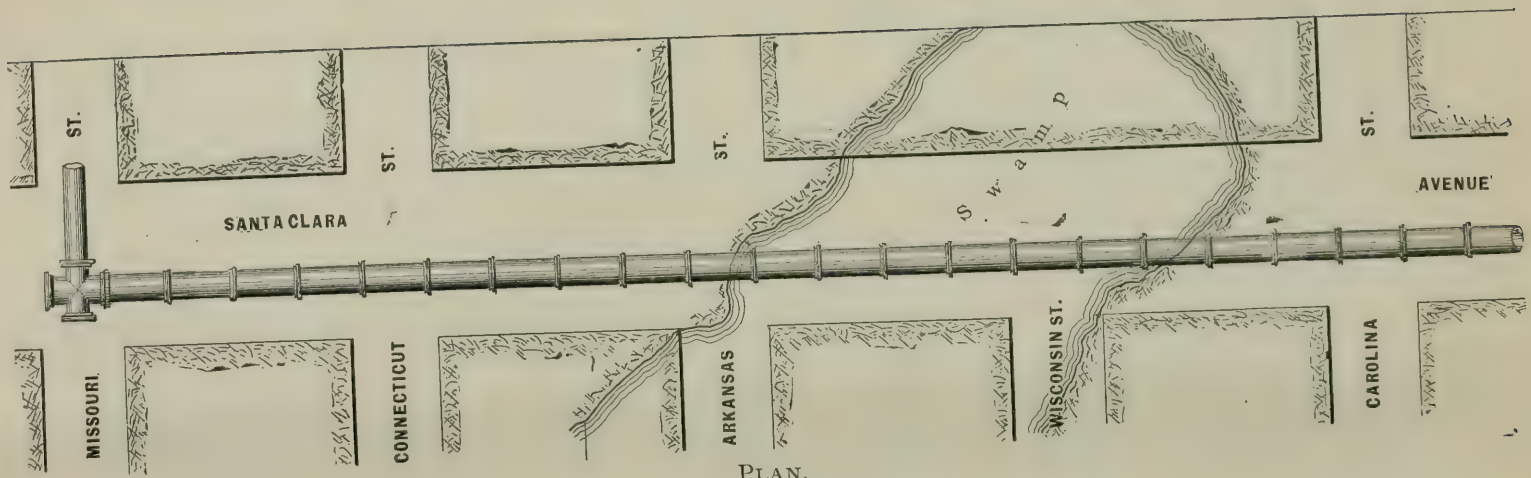
BY J. B. CROCKETT, Mem. Tech. Soc.

[Read March 3, 1893.]

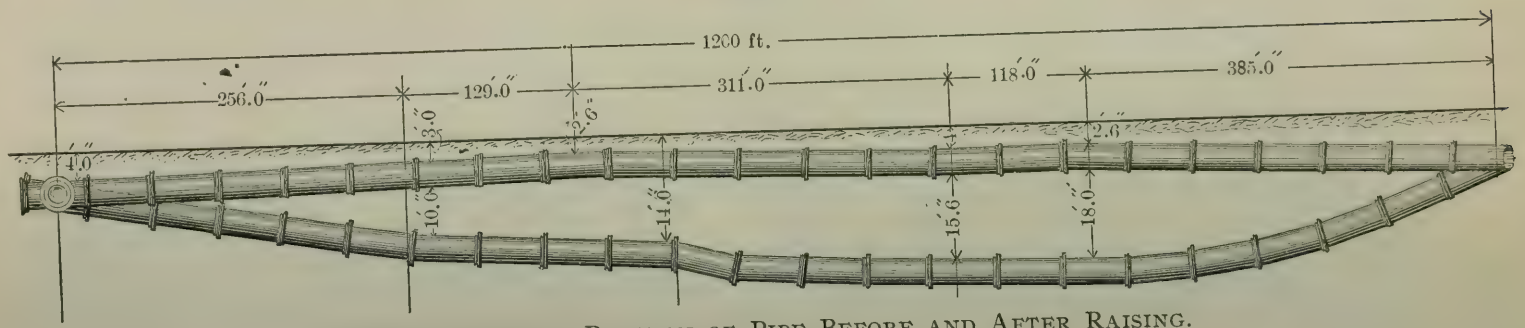
Usually, large engineering operations, such as any class of construction work, are attended with a certain amount of pleasurable anticipation, as the plans are being perfected, and a degree of pardonable pride as the final results are contemplated; but once in a while we are confronted with engineering emergencies that require more skill and watchfulness for successful handling, yet are totally devoid of any of these compensations. This paper deals with one of the last.

What is now known as the Potrero Station of the San Francisco Gas Light Company, was built from 1869 to 1871. It is situated on the Bay Shore, and is bounded by Georgia, Humboldt, and Sierra Streets on the land sides.

The situation of the plant is favorable, with one exception, that the extreme southern part of the City is isolated from the large gas-consuming districts, by water-ways and marshes, extending westward far into the city. To provide an outlet for the gas made at these works, and avoid crossing Channel Creek, or the mud flats which mark the former boundaries of old Mission Bay, it became necessary to lay a twenty-four-inch cast iron main from the works to a point crossing Kentucky Street at Solano Street, thence over



PLAN.



SECTION, SHOWING POSITION OF PIPE BEFORE AND AFTER RAISING.

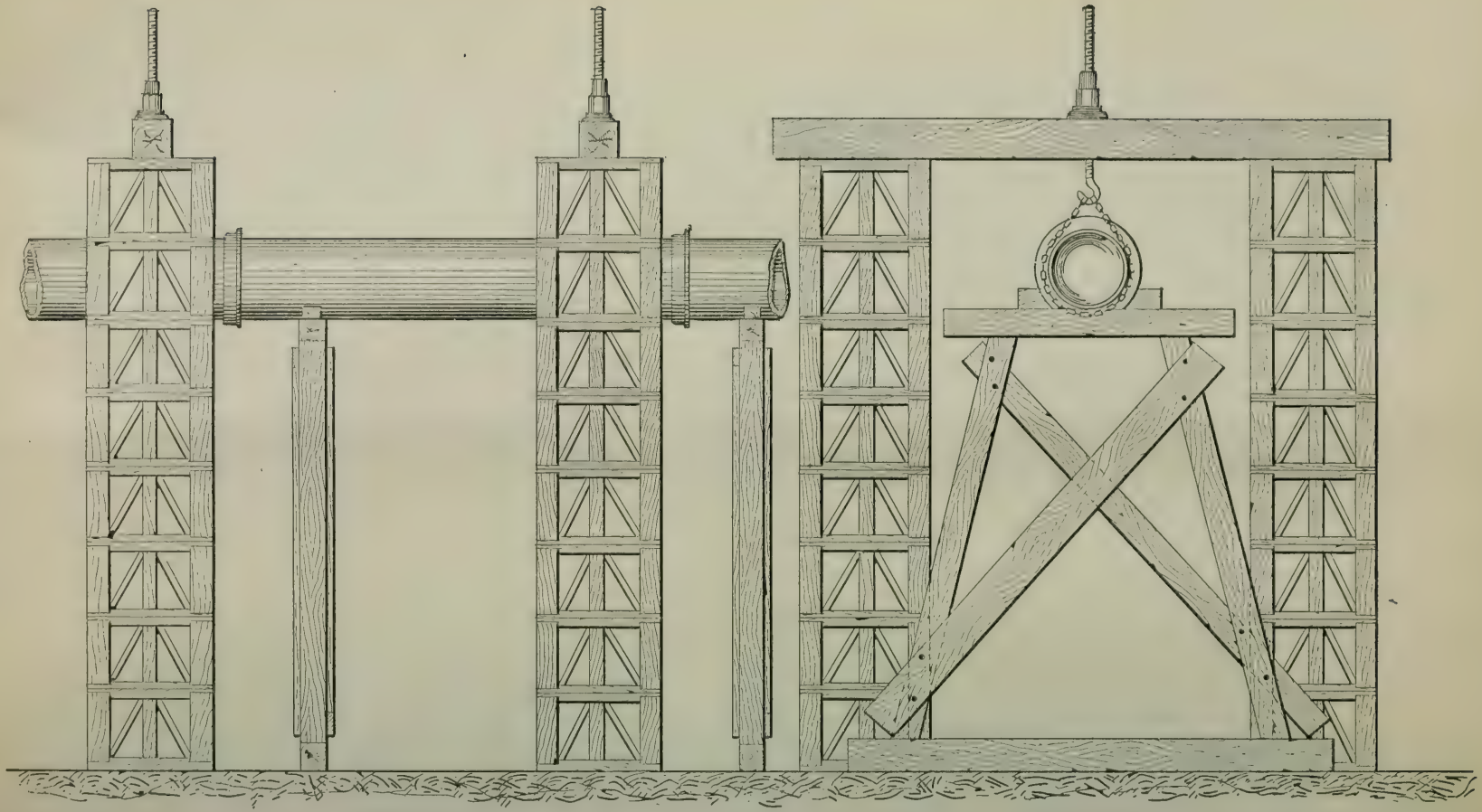
the high hills to the west to Mission Street, and thence in a northerly direction down the hill to the marsh at Santa Clara Avenue.

The pipe was laid beneath the surface of the marsh on Santa Clara Avenue, from Missouri to De Haro Streets, a distance of 1,424 feet, then in a northerly direction, 510 feet, to Center Street. From Center Street the large main enters the heart of the City through Ninth Street, and is there connected with the ramification of pipes which supply the city with gas.

Where the pipe crosses the marsh on Santa Clara Avenue, it was laid with about three feet cover of earth, and to all appearances on as good foundation as many other gas mains in the City. At this place the ground was below the official grade, from two feet at the highest, to eighteen feet at the lowest points, but at the time the pipe was laid, no other nor more desirable location was available, nor could the ultimate grading of these streets be anticipated. On a sunny day, with the pipe snugly laid in the marsh, Santa Clara Avenue was like a peaceful valley, but after notice was served that the streets in the vicinity were to be graded, it proved to be a veritable "slough of despond." The first notice was the intention to grade Santa Clara Avenue from Missouri to Carolina Streets, and the intersecting streets. This covered four blocks or about twelve hundred feet of the twenty-four-inch main, and it became necessary to uncover and raise it before the filling was begun.

Before proceeding with a description of the raising of this large pipe, I want to lay stress upon the fact that this pipe was the main artery of the city's gas supply, which was constantly under pressure, and through which over three fourths of all the gas supplied by the San Francisco Gas Light Company was drawn. This was previous to the building of the new works at North Beach, and there was no substitute of any kind for it.

On December 16, 1890, work was commenced raising the pipe on Santa Clara Avenue, between Mission and Carolina Streets. It was necessary to raise the main without cutting or breaking it, and its success depended in a great measure on its flexibility due to lead joints. Had the joints been of cement, as they are almost uniformly made in Eastern cities, the rigidity of pipes and joints would, without doubt, have caused a break, or perhaps many serious breaks, but with about one hundred lead joints, 4¼ inches deep and half an inch thick, it became possible to raise the main without a fracture.



Side View

End View

Structure Showing First Manner of Lifting and Supporting Pipe.

The first section to be raised, weighed about 260,000 pounds, and the method employed in raising it was as follows: The pipe was first uncovered, the trench extending to the bottom of the main, and at intervals of 12 feet of its entire length, house mover's frames were placed on each side, one above another, to the desired height. A 12 by 12-inch timber was placed across these tiers of frames, passing over the pipe just behind each joint. Heavy chains were passed around the pipe, back of each heel, and what is known as a two-inch "holder screw," was hooked to each chain and passed through a hole in the timber above. On the upper surface of the timber was an iron washer, and on this rested the large nut on the thread of the holder screw.

After taking up the slack on each chain, a man was detailed with a wrench to each screw, and at a signal from the foreman each man took one turn of the wrench, and the pipe was gradually raised. As the main was raised from the marsh, a gang of men was employed in blocking under it, to prevent its falling in case of the accidental breaking of any part of the lifting machinery, until finally, when it was raised to the desired height, or about three feet below the official grade of the street, the pipe was temporarily supported by house frames. Seven hundred and eighty of these frames, each 2½ feet high, were used in raising and supporting the pipe.

The next step was the permanent support of the pipe previous to the filling of the street. This was done by constructing a series of wooden trestles, five feet wide at the top and twelve feet wide at the bottom. They were made of 8 by 8-inch uprights with a sill underneath, and a cap at the top of the same dimensions, and braced diagonally by pieces 2 by 10-inch on each side. After the completion of the trestles, all the other supports, including the house frames used for raising, were removed, and apparently nothing remained to be done but to fill in the street with solid filling. The pipe had been raised without accident of any kind, all the joints had been re-caulked where they had drawn, and the permanent supports were amply strong.

The filling of the street was commenced immediately after the pipe was raised. This was done by taking the rock from the hills east and south of the fill, and transporting it in cars to the dump. This work was done by a contractor for the City.

As fast as the street was filled to grade, a gang of men kept the twenty-four-inch pipe uncovered, and all went well until the fill

reached the corner of Santa Clara Avenue and Arkansas Street, when, on Saturday, April 11, 1891, at 11 o'clock P. M., the northerly side of the street began to slide toward the north, carrying the pipe and its supports with it. The main settled four feet and slid to the north three feet, and the wooden trestles were canted over in the direction of the slide.

A gang of men was immediately put to work shovelling the rock and earth away from the trestles to remove the pressure against them, and to distribute the material under the pipe. The following day a number of teams were employed to cart the material from the face of the dump, and to spread it along the line of the pipe, under and on each side of it. The object in thus carting the rock was to distribute evenly the load on the marsh, and gradually raise the whole street to the level of the pipe, instead of keeping up to the street grade, and presenting a steep face at the dump. Carting rock was continued until we had filled in solid under the pipe and had built a cartway about nine feet wide on each side of the pipe, level with the bottom of it. This required the handling of five thousand loads of stone. As the stone was hauled ahead and loaded on the marsh, the street continued to settle, carrying the pipe with it.

Four days after this first trouble, the crossing of Arkansas Street commenced to settle very rapidly, and in fifteen minutes the street had gone down four feet. The large body of rock settling in the mud, raised the surface of the marsh at a point about one hundred feet north of the street, about five feet high, and opened a crevice a foot wide. This was a natural consequence of the displacement of mud by the heavy fill of stone, but why over half of the filled street should slide bodily toward the north, at the same time, and where and when it would bring up? were perplexing questions. To ascertain the exact nature of the underlying strata of the marsh, and solve at least one of these problems, we caused soundings to be made in lines ninety-six feet long, extending from south to north, at right-angles to the pipe, by driving a half-inch iron bar into the ground. The crust of the marsh was found to be fairly firm to a depth of three feet, consisting of a sort of marl.

At the northerly side of the street, after passing through the crust, the bar sank into nineteen feet of soft mud, and then reached hard bottom. At the middle of the street the bar went down through seven feet of the same mud, while on the south side there were but two feet and six inches of the mud under the crust of the marsh. The stratum underlying this mud was an extremely hard clay.

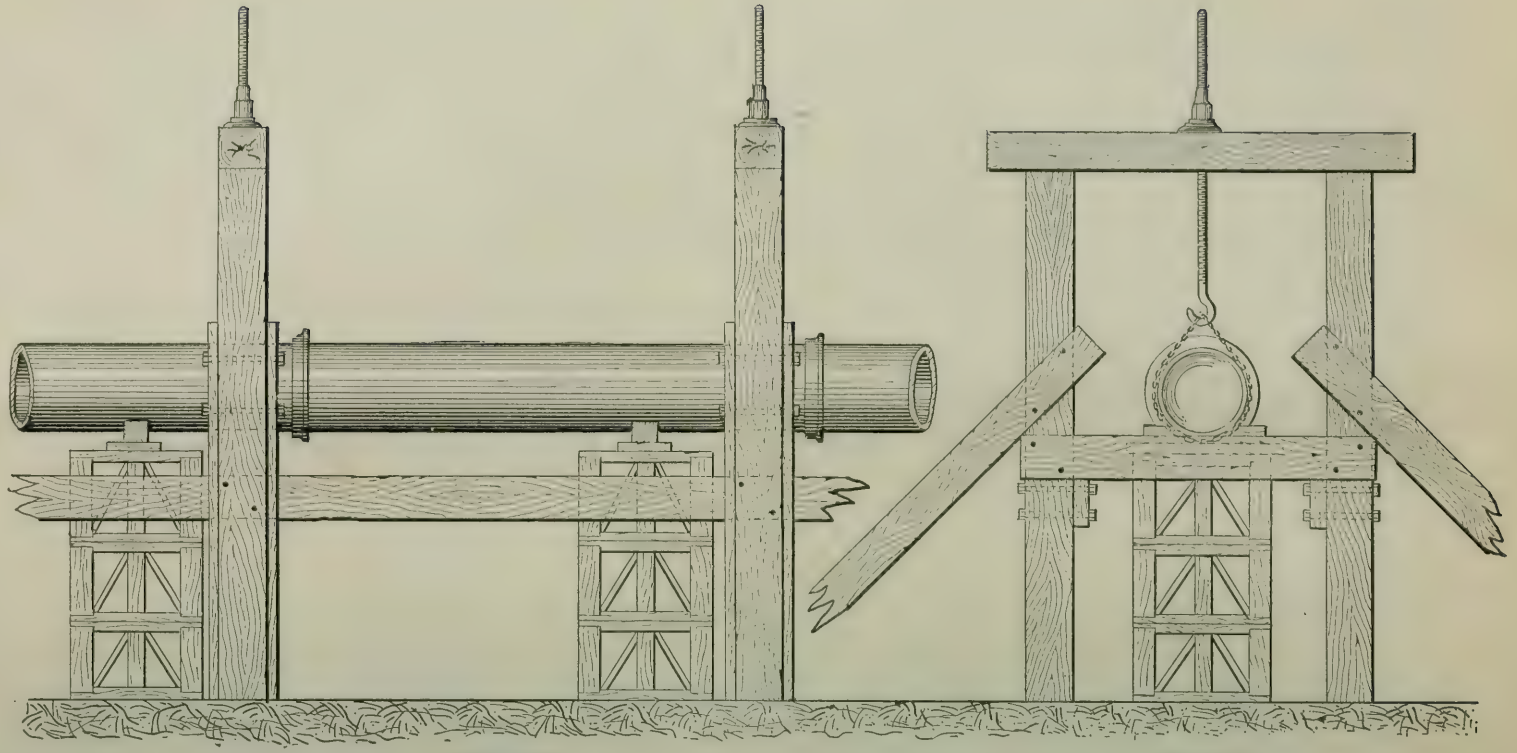
These soundings explained to my satisfaction the cause of the body of rock sliding towards the north. The surface of the marsh was nearly level, but the thick body of soft alluvial mud was resting on a subterranean side hill of hard clay, sloping toward the north with a trend of fourteen degrees, and as the rock fill sank into the mud it slid, mud and all, down the slope of the hard bottom.

The soundings also explained the sudden and spasmodic settling of the fill. The three feet of firm crust over the marsh offered a resistance to the load of rock piled upon it, until the load was sufficient to overcome the resistance, when the crust broke, letting the entire fill settle from four to five feet at a time.

After the second settling of the pipe it was necessary to resort again to the house frames for raising it, as the wooden trestles had sunk into the marsh and were almost useless. After raising the pipe with screws to the proper height, jack screws were used for forcing it laterally towards the south, back into its proper line. By continuous wedging under the pipe, using in all about ten cart loads of wooden wedges, we arranged to keep the pipe in its place, until May 1st, when another settlement occurred, opening long fissures in the fill, and raising the surface of the marsh to the north about nine feet, and at the same time opening several long cracks nearly two feet wide. This was the most trying period of the whole undertaking, and as a safeguard I laid a line of twenty-inch pipe on the surface of the marsh, south of Santa Clara Avenue, and cut the twenty-four-inch pipe between Missouri and Arkansas Streets, and at Carolina Street, and put in **T**'s twenty-four by twenty.

This was done so that in the event of the destruction of the twenty-four-inch main, we could, by making short connections with the twenty-inch main, provide a way to deliver gas to the City temporarily. Fortunately, however, this new line was never used, but its presence was a source of relief.

The last serious settlement occurred on May 15, 1891, when 12 by 12-inch timbers, thirty feet long, were placed under each length of pipe, back of the joints, and the end of the timber towards the north was blocked up about two feet higher than the south end. With this precaution we were enabled to keep the pipe wedged up in place, although it was a constant source of worry and annoyance, until the rock fill had found a bottom on the hard clay and the street was brought to grade. At the crossing of Arkansas Street, which was the worst part of the marsh, the main was raised at the beginning sixteen feet, and the sum of all the settlement at that



Side View. End View.

STRUCTURE SHOWING SECOND MANNER OF LIFTING AND SUPPORTING PIPE.

point, was fourteen feet, that is, the entire fill settled into the marsh a distance of fourteen feet, so that it was necessary to raise the pipe in all, thirty feet, to maintain it at the sixteen-foot level.

The contractor continued filling in, until July 31, 1891, and the average amount of material dumped each day, from May 1st to July 31st, was twenty-three train loads of nine cars each, or about two hundred and seven cubic yards per day. As the contractor completed filling the street to grade, the pipe was kept uncovered, and a 12″× 12″ timber was placed across each length of pipe, resting on blocking and wedges, chains were passed around the pipe and holder screws were used for sustaining it. For months it was necessary to keep careful watch of the pipe, and men patrolled its entire length day and night, driving wedges and taking up the slack on the chains, wherever needed. In fact, during all this time Santa Clara Avenue became one of the Company's telephone stations, and for a while was the one most frequently used.

Finally, in November, 1891, the street had stopped settling, the timbers and screws were removed, and after carefully tamping the earth under the pipe, the trench was filled. Early in October, 1891, notice was received of the intention to grade Santa Clara Avenue west from Carolina Street, and as the twenty-four-inch main extended west as far as De Haro Street, (304 feet) it was necessary to raise it out of the marsh. At De Haro Street the pipe turns at a right-angle, and extends to Centre Street, (510 feet), and it was necessary to raise the entire 814 feet an average of about eight feet in height.

A pile structure was built to raise and sustain the pipe. Sixteen-inch piles, fifty feet long, were driven through the marsh into the hard clay bottom. These piles were spaced twelve feet apart, and were five feet from the pipe on each side. Ten feet outside of each standard pile a brace pile was driven and sawed off two feet from the ground. On each side of the standard piles, extending down to the brace piles, were diagonal braces 4″× 12″. Caps 12″× 12″ were placed over the main, resting on the top of the standard piles, and a screw passed through a hole in the middle of each cap. The pipe was raised as before described.

When the pipe reached the proper grade, waling pieces 4″× 12″ were bolted on the inside face of the standard piles, and across these were placed two planks 4″× 12″, on edge, resting on the waling pieces and bolted through the piles. The pipe rested on these 4″ × 12″ cross pieces, and was prevented from rolling by

pieces of 4″ × 4″. The entire wooden structure was securely bolted together.

The standard piles were for raising and permanently supporting the pipe, and the brace piles and the diagonal braces were to withstand any side thrust caused by sliding of the marsh.

One of the difficult features of this piece of work was the bracing of the right-angle in the main, at the corner of Santa Clara Avenue and De Haro Street. This was accomplished by driving ten piles around the **T** at the corner, and by a system of diagonal braces. To prevent the pipe from drawing apart, iron bands were bolted around it at the corner, and these bands were connected on each side by rods with turn-buckles.

After the pipe was raised and supported, the 12″ × 12″ caps were removed and the tops of the standard piles were sawed off below the grade of the street. As the street was filled, the pile structure stood the strain of the street settling, but there was little or no lateral thrust, as the clay under the marsh was nearly level at this point, and the fill did not slide.

This piece of work was not subject to any of the unfavorable conditions that so seriously affected the first part of the work. In fact, the method employed to raise the first section would have been successful in raising the second section; but it is doubtful if any wooden structure would have withstood successfully the various forces exerted to overthrow it, at the crossing of Santa Clara Avenue and Arkansas Street.

REGULAR MEETING, MARCH 3d, 1893.

PROCEEDINGS.

MINUTES.

The meeting was called to order by the President, C. E. Grunsky.

The minutes of the last regular meeting were read and approved.

The following names, having been balloted for, were declared elected:

For Member:

Lawrence Thompson, Civil Engineer.....San Francisco.

For Associate:

Edmund McNevin, Navigator.....San Francisco.

The following propositions were read and referred to the Executive Committee:

For Members:

P. E. Leat, Electrical Engineer, San Francisco; proposed by C. E. Grunsky, H. E. C. Feusier and Geo. F. Schild.

Thomas H. Leggett, Mining Engineer, Bodie, Cal.; proposed by W. F. C. Hasson, C. A. Stetefeldt and Otto von Geldern.

For Junior:

John James Williams, Topographer, U. S. Geological Survey; proposed by H. E. C. Feusier, R. E. Bush and Otto Von Geldern.

Mr. Augustus Knudsen, Civil Engineer, submitted the following communication, which was ordered received and placed on file:

To the Secretary of the Technical Society of the Pacific Coast:

SIR:—The near adjournment of the Legislature, coupled to the fact that no definite result has as yet followed from the discussion regarding the means of realizing a topographical map of California, suggest the fear of an abandonment of the project, or at least of suspending it for two years. With the aim of preventing such an issue,

I venture to suggest another course, viz., that the scheme be carried out by private enterprise under the Society's impulse, if it is granted that such a map is of itself a profitable undertaking.

The Society's action could be exerted in the following ways :

1st. By naming an executive committee for the unification of labors, with powers to enlist the interest of capitalists, corporations or proprietors in the scheme.

2nd. By parcelling out the State into ten or more transverse zones from Sea to *Sierra*, each to be placed under a commissioned engineer duly authorized to raise the necessary funds by personal exertions, or pledging percentage of returns, and whose technical work would be endorsed by the Society upon photographic evidence in addition to ordinary tests. These engineers would have seats in the committee.

3d. By requiring that work begin with details, as involving possible immediate returns to the operating engineers, and also as a tribute to public opinion, and to continue ascending in rank until results were ready to be embodied into one whole, when the committee would be specially authorized to arrange and print the work.

Respectfully Yours,

A. KNUDSEN,
Member Tech. Soc.

San Francisco, Feb. 25, 1893.

Mr. Jos. B. Crockett, President of the San Francisco Gas Light Co., then read a paper entitled "An Experience with a 24-Inch Gas Main," which was discussed.

A courteous invitation was extended by Mr. Crockett to the members of the Technical Society, to visit and inspect the large gasometer near Laguna and Bay Streets, San Francisco. This invitation was accepted by the Society for Saturday, March 11th, for which occasion the Secretary was instructed to issue suitable cards.

Adjourned.

OTTO VON GELDERN, *Sec'y.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

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(VOLUME X. NO. 3.)

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SOME PROBLEMS OF MUNICIPAL ENGINEERING.

BY CHARLES D. MARX, Mem. Tech. Soc.

[Read April 7th, 1893.]

A French scholar, writing in Lyons in 1854, made the statement that our country, so proud of its progress in mechanics and in the possession of technical aids, as, for instance, steam, greater than any controlled by the ancients, nevertheless is far from accomplishing, for even the largest of our cities, what the Romans accomplished for the smallest town under their control, and that often in spite of the greatest difficulties. This seems a bold statement, but the truth of it will be apparent if we pass briefly in review what the Romans accomplished in the solution of some of the municipal problems which we find staring us in the face today.

These problems of water supply and sewerage, of the laying out and paving of streets, of the removal of garbage and dust, of public parks and baths, are not problems which the human race is called upon to solve for the first time. If we are willing to profit by the progress made in lines, mechanical and industrial, why do we show an inclination in municipal matters, and especially in sanitary municipal matters, to always revert to a primitive state of things; to build up our structure from the foundation, when we could safely

build on the foundations laid centuries ago, which have become firmly settled by this time? But to the proof.

I have chosen as an illustration the city of Rome, not only because it is a city of the past, but also of the present, because it, too, in spite of centuries of experience back of it, had until recent times failed to profit by them. Originally a number of hills near the banks of the Tiber, and a few miles from its mouth, were settled by a grazing and agricultural community, and such it remained for some time. About 200 years or so after the founding of the city, toward the end of the reign of the kings, agriculture and cattle raising were still carried on within the limits of the city. The streets were unpaved and filthy, human and animal excreta piled around the miserable dwellings lay festering under the hot Italian sun. It is not strange, therefore, that in a city surrounded on three sides by poisonous marshes, without any system of drainage, and with an internal condition of affairs as sketched above, it is not strange, I say, that malarial fevers carried off hundreds, perhaps thousands, of human beings. As Doctor Lauciani says: "The clearest proof of the virulence of malaria in the first century of Rome is afforded by the large number of altars and shrines dedicated by its early inhabitants to the goddess of fever and other kindred divinities. It was not, however, until the *prayers* to the gods were supplemented by *action* on the part of the citizens and administration that a change for the better took place. To Tarquinius Priscus, the fifth of the kings, must be given the credit of having directed the first systematic works for the drainage of the town, and it was for this latter purpose alone that the first sewers were constructed. They were to give an outlet to the ponds, swamps, and marshes which stretched along the valley between each couple of hills, rather than to serve as sewage carriers in the modern sense of the word, for at that time Rome had not yet entered upon its period of water works construction. The fact that a number of these sewers have stood for more than two thousand years, and that one of them at least is in use even at the present time, speaks volumes for the quality of municipal work in those days, No cavities back of the arches full of empty cement barrels were found, as was recently the case in the construction of the Croton aqueduct for the city of New York. No scamped work, as the investigation of some of the public works in Washington disclosed. It is likely that to a body of reliable contractors was added a corps of honest inspectors of public improvements. The claim is advanced that we have lost the art of making mortar as strong as

the Romans, and hence the poorer quality of a good deal of our municipal work. I am inclined to look elsewhere for the cause. But to return to Rome.

The sewers, of which I have just spoken, emptied directly into the Tiber, and the full effects of such an arrangement made itself felt as the city grew, as the sewers became true sewage carriers, and as the pollution in the river increased daily. Having no knowledge of the modern germ theory of disease, the Romans may well be forgiven for this error in the planning of an otherwise admirable system.

That the Roman sewers primarily served the purposes of drainage is further evidenced from the fact that they antedated the construction of aqueducts or water works by some centuries. A Roman water works' superintendent, writing in the first century after Christ, states as follows: "During four hundred and forty-one years the Romans satisfied themselves with the use of such water as they could obtain on the spot, from the Tiber, from wells, or from springs." This period was followed by that of the construction of those wonderful masterpieces of engineering and architecture — the Roman aqueducts. It is true that in our modern times most of these structures would not be erected, but the Roman, ignorant of the use of cast and wrought iron for pipe material, had to construct those masonry channels in which to carry the water across deep valleys and gorges. I do not think that even the most rabid modern materialists are likely to bewail the Roman ignorance on this score. Dr. Lauciani concludes, as to the extent of the Roman aqueducts, that "eighteen springs were collected and canalized by the Romans from distances varying from a minimum of seven and a half miles to a maximum of forty-four; the waters were brought to Rome by means of fourteen aqueducts, the length of which varies from a minimum of eleven miles to a maximum of fifty-nine. The average length of these aqueducts amounts to three hundred and fifty-nine and one third miles, of which three hundred and four miles are underground, fifty-five above ground; the channel being carried on the top of really triumphal arcades at prodigious heights, sometimes exceeding one hundred feet." A tunnel, three miles in length and three feet by seven feet in cross section, between Tivoli and San Gericomio is another interesting feature in connection with the works for the water supply of Rome; but not into the city alone, into the surrounding districts also was carried an almost inexhaustible supply of pure cold water. Assuming for Rome a minimum popu-

lation of 2,000,000, which by some is supposed to be fifty per cent. in excess, we find that one hundred and twenty gallons of water were furnished per inhabitant per day; if there were but a million then we have two hundred and forty gallons per day, a quantity more than twice as great as is usually assumed in water supply estimates for large modern cities.

Beginning with the year 11, before Christ, water was furnished free of cost. Up to that time a small tax had been paid, but it could not have been a heavy one, for Strabo, writing in the latter part of the first century, B. C., mentions the existence in almost every Roman house of reservoirs, pipes, and fountains. Such a quantity of pure, clean water furnished for practically nothing led, naturally, to great habits of personal and municipal cleanliness, a matter of so much greater importance since closely-packed tenement houses and narrow winding streets would otherwise have exerted a far more pernicious influence than they did.

Intimately connected with the lavish water supply grew up a system of public baths, such as the world has never seen before or since, a system not confined to the city alone, but extending far into the outlying villages, into the country, and into the provinces. In fact all the people, even the country people, became so accustomed to their daily bath that they sorely felt being deprived of it. Seneca sees in this all-pervading cleanliness a sign of the decadence of the times, for formerly, as he puts it "a daily washing of the hands and feet and a bath once a week was deemed sufficient." At the end of the third century after Christ, Lauciani says: "Rome numbered eleven large thermæ, and 926 smaller ones conducted under private enterprise. The baths of Caracalla alone could accommodate at one time 1,600 people; the baths of Diocletian, 3,600; taking 1,500 as the average accommodation of the public thermæ, and 50 as that of each of the private baths, we learn that in ancient Rome at any minute 62,800 citizens could restore their strength in baths of every description; and this without bringing into the calculation, the Tiber, the Arnio, the lake Agrippa, and the bathing accommodations with which every Roman house was abundantly furnished." The cost of a bath was about three eighths of a cent.

The small agrarian village of which I spoke as Rome in the beginning had grown in the course of time into a capital as important as any in modern times. The lack of foresight in planning systematically for the development of the town had carried its own punishment in its wake. When in the year 390 B. C., about 363

years after the founding of the city, it was sacked and burned by the Gauls, an opportunity was offered for remedying the errors of the past in rebuilding the city. But no advantage was taken of this opportunity. Irrespective of old street lines, without regard to any plan, without regard to the already existing system of sewers, the new city was built upon the ruins of the old. The Emperor Augustus, in the last century before Christ, tried his hand at improving the network of city streets, he succeeded but slightly. Far more successful, because less conservative, was Nero in the year 64 after Christ. He had to resort to strategy in order to carry out his plans for improving the city, however, because superstition and the greed of private owners of property balked his way. The method he used was simple, but unfortunately cannot be used in this 19th century. Lauciani summarizes the work done by Nero as follows: "He ordered his favorite architects, Severus and Celer, to draw a new plan of the city, and to draw it according to the best plans of hygiene and comfort. Then he caused an enormous quantity of wooden booths and tents to be secretly prepared, and ordered fleets of grain-laden vessels to be kept in readiness to sail from the various harbors of the Mediterranean at a moment's notice. Having taken all these precautions, and insured the success of the strategem as far as human foresight could, Nero set the whole city into a blaze of fire, and did it so neatly that in the fourteen regions, or wards, into which Rome had been divided by Augustus, three were annihilated completely, and seven for the greater part, and yet not a single human life seems to have been lost in the gigantic conflagration. The homeless crowds found a ready and comfortable shelter under the booths and tents raised by thousands in the public parks and squares. At the same time a large number of vessels laden with grain from Sardinia, Sicily, Numidia and Egypt appeared at the mouth of the Tiber, and relieved the emperor from any anxiety as far as famine was concerned. These vessels, as soon they had discharged their cargoes, were filled up again with the debris of the conflagration, which they threw into the marshes surrounding the delta of the Tiber.

"Even in our age of progress, material, improvement, and comfort we cannot help admiring the profound wisdom shown by the two imperial architects, Severus and Celer, in designing and rebuilding the city. The straight line and the right angle were followed, as far as could be done in a hilly country, in tracing the new streets and avenues through the still smoking ruins. Haste and irregular

constructions were forbidden. The line of frontage of each new building had to be sanctioned and approved by one of the official surveyors. Large squares were opened in place of filthy thickly-inhabited quarters. The height of private houses were supposed not to exceed double the width of the street, and porticos were to be built in front of each one to provide the citizens with cool sheltered walks in case of rain or excessive heat. Lastly wooden ceilings were excluded from the lower story of private dwellings, and absolute isolation on every side was made compulsory."

But even this reconstruction of the city could not do away with all the existing evils, it was but a partial remedy at best. Even after the fire, according to the consensus of opinion of the ancients, the houses were pushed skyward. Juvenal and Pliny are cited to this effect by my informant. There seems to be every reason to believe that, with a maximum width of the main streets of from fifteen to twenty feet, the fronts of the houses were often as high as fifty to sixty feet, whilst the rear part of the houses was usually much higher. With a population as large as that of New York, crowding and jostling in these narrow thoroughfares, we need not wonder that in the history of the city it soon became necessary to forbid all driving in the streets during the day time. All teaming and hauling had to be done during the night, and in the early evening and morning hours. To this there were a few exceptions. Materials for public buildings could be hauled through the streets of the city during the day time. Garbage collectors, and the priestesses of Vesta were also allowed to drive through them. Surely this is a case of the meeting of extremes.

But as I have said above, all regulations, all partial reconstructions of the city could not make amends for the lack of a wisely conceived city plan in the beginning. The Rome of the present century — of our days in fact — is taking the final steps for the correction of the errors of the past. Whilst criticising thus freely this, the most serious defect in the municipality of ancient Rome, there are a few other public institutions which these far-seeing people provided, from which we cannot withhold our unbounded admiration. But the two of which I am about to speak must not be counted among the number.

It seems strange that in so progressive a city as Rome no attention should have been paid to the matter of public lighting of the streets. With approaching darkness the houses and stores were locked and bolted. Poor people compelled to be out at night

carried their own lights, people of means were preceded by torch-bearing slaves. In spite of a large police force of seven thousand men, however, the streets of Rome were not safe at night. Assassins lurked in the deep shadows of columns and porticos, and happy was the belated citizen who suffered nothing worse than being tossed in a blanket by the roystering sprigs of nobility out for a lark.

I have already stated that a system of garbage collection existed, but the method of the disposal of this material was as crude as it is in most of our cities of the present day. Everything was carted to huge dumps and left to decompose in the open air. That an intolerable nuisance was thus created became apparent to the Romans as long as two thousand years ago. Sanitary rules to abate, or at least mitigate the nuisance, were passed, and Dr. Lauciani in his excavations has unearthed some of them graven on stone. Here is the text of one: "C. Sentius, son of Caius the Praetor by order of the senate has set up this line of terminal stones to mark the extent of ground that must be kept absolutely free from dirt, and from carcases, and from corpses. Here also the burning of corpses is strictly forbidden." Another hand, probably that of a man living in the neighborhood and within reach of the effluvia of the place, had written in huge red letters, the following entreaty at the foot of the official decree, "Do carry the dirt a little farther, otherwise you will be fined." This line of stones, beyond which the refuse of the town could be legally thrown and be allowed to putrify under the burning sun, was only four hundred feet distant from the walls and embankments of Servius Tullius. On the day of the discovery of the above mentioned stones, June 25, 1884, Dr. Lauciani was obliged to relieve his gang of workmen from time to time, because the smell from that polluted ground (turned up after a putrefaction of twenty centuries) was absolutely unbearable, even for men so hardened to every kind of hardship as his excavators. The greatest of these nuisances, the dumping ground in the vicinity of the Esquiline Cemetery, and the latter itself, were covered over at the beginning of our era by twenty-five feet of soil, and the one third of a square mile turned into a garden. This is the place at which the excavations above referred to were made. Can any modern board of health look for stronger proof in support of its measures than the instance just cited?

But though the street system of ancient Rome, the methods of cleaning the same, and of the disposing of the garbage and waste left much to be desired, we must admit along other lines amends

were made to the greatest extent possible. Open squares, gardens, and parks innumerable in the city counteracted the effects of the narrow, winding, and stifling streets, in which the smoke of the kitchens was mixed with clouds of dust. Many of the parks, though owned by private parties, were opened to the public. From roofs and balconies, flowers and shrubs exhaled their perfume, and shaded walks under laurel and plantain tempted the wanderer on the Campus of Mars.

A brief reference, before we leave this great municipality, to the markets and slaughter houses. Here too we find the most liberal and painstaking provisions; the ample water supply proving a great help in keeping these places sweet and clean.

Turn we now forward to the end of the present century; can it be honestly stated that our municipalities of today have learned the lesson taught by the past? Bitter experience has come to the older cities on the Continent,— disease, death, and waste of moneys, the necessary consequences of such a heedless course. Are we in the new world to follow their example, and not rest content until we have been taught by this same stern taskmaster of our own experience? Do you not know that in every one of our communities these old world problems must in turn arise, and additional ones caused by our modern industrial development?

Water supply and sewerage, street paving, sprinkling and lighting, are these not subjects dear to the taxpayer's pocket? Is not the solution of these problems one of vital interest to every citizen of a community, looked at from a higher standpoint than that of mere money? Yet I feel no hesitancy in saying that the importance of these subjects is far from fully recognized by the majority of our citizens. If we look at the matter merely from a business standpoint, the one which the adherents of every short-sighted policy prefer to take, I think it can be shown, by a calculation made by Professor Delos Fall with reference to typhoid fever, that the unsatisfactory solution of these problems pays.

"Forty thousand people in the United States die every year from typhoid fever. For every person who dies with this disease at least ten are sick. So there are sick in the United States every year from this one disease on an average, 400,000 people. For every person thus sick the time and attention of at least one other person is demanded either as nurse or otherwise. Then 800,000 people in the United States each year are either suffering from or attending those who are suffering from this disease. You may go

further in the computation. The average duration of this disease is about 28 days, or in the aggregate, 22,400,000 days. If money considerations could ever be placed beside the value of human life, an easy estimate at say one dollar a day for each of these would show a financial aspect of the case to be very serious indeed. This from one disease alone. Add to it the large number of other filth diseases with their attendant sickness and death, and the problems before us for study at this time stand out in gigantic proportions."

Take the sanitary conditions of some of our lake cities as regards the important relation of water supply and sewage disposal, The most striking instances that occur to my mind just now, are Cleveland, Milwaukee, and Chicago. Though we know that after the destruction of the aqueducts at Rome the populace for a time again drank the water from this same Tiber into which it discharged its sewage, we also know that this was at a period of decadence of the town. Unfortunately in the case of the three cities mentioned above at least, and many more that I might add, the order of things has been reversed, and during their period of growth and development they propose to drink from those bodies of water into which they discharge their sewage. Outlet of sewer and intake of water works are so placed that safety of the cities' water supply against pollution cannot be guaranteed. The recent scare in Chicago is too fresh in your minds to need more than a passing mention. As that city proposes to receive the nation as its guest this year, it is a matter of supreme importance to all of us that no such danger should occur again, that the city should push energetically towards the completion of its well designed sewerage system.

I have just chosen for illustration examples from the middle United States. Perhaps I might find some nearer home, but as it is always more comforting to realize that someone else is worse off than we, let us glance but a moment at the sanitary condition of London, which oftenest of modern cities has been compared to Rome. Repeated Parliamentary commissions have sat upon the question of water supply and sewerage for this commonwealth, but up to today no satisfactory solution of the problems has been adopted. Private companies as heretofore, continue to supply the city with limited amounts of water of greater or less purity, often less. The Thames until recently dragged its sewage polluted waters seaward. It is to be hoped that the newly elected council of London will at last be able to deal in a satisfactory manner with these important problems.

If so little attention has been paid in many of our modern cities to such vital questions as water supply and sewerage, you may well believe me that still less attention has been paid to such apparently minor matters as decently paved streets, kept in good repair, swept, and sprinkled, efficient systems for the collection of garbage, public markets and slaughter houses, and last but not least, public parks. The prevailing opinion in almost every city of the United States is that a pavement of any kind, no matter how poor, once put down will take care of itself. Well, it usually does, but in a way hardly expected by the tax payer. If the old truism of "a stitch in time saves nine," can be applied to anything, it certainly can to such a subject as street paving, no matter whether the material is wood, stone, or asphalt. Timely repairs and cleanliness are as much a matter of life and death to a pavement as they are to a human being. The additional fact that dirty and dusty streets are not the only cause of their own destruction, but must also be held responsible for the destruction of many lives, is, perhaps, not apparent at once, so let me quote from an interesting article by Dr. Bennett in the June *Sanitarian*:

"The atmosphere we breathe is filled with suspended matter of the foulest and filthiest kind, in the shape of dust particles ground from the pavement, ashes, the dejections of animals, the dried and pulverized sputa of a million persons, garbage, dead animals and offal, besides the poisonous gases from ten thousand factories and sewers. In 1872 I mentioned, without then fully recognizing the importance of the suggestion, the possibility of micro-organisms in the suspended matter of the atmosphere playing an important part in the production and perpetration of catarrh. In opposition to this it may be said that the disease is very generally prevalent over the whole country. But this statement requires qualification. Catarrh is most common in large cities, and the dirtier and dustier the place the more prevalent it is. Other things being equal, I believe the more dust in the air (pulverized filth I mean, not clean dust) the more cases of catarrh one will meet."

Street sweeping and intelligent street sprinkling are therefore, it would appear, also matters of considerable importance in a city's sanitary condition.

What shall I say of the question of garbage and refuse, collection and destruction? Does not the extract which I quoted from Dr. Luciani prove fully the necessity of intelligent systematic action, lest our negligence stink to heaven two thousand years from now;

as did that of the Romans in this century? The last report of the special committee of the American Public Health Association gives a most discouraging resumé of the condition of even our largest cities in this respect. Many of them, almost all of the small ones, are still following Rome's example. It is time that a halt were called and this waste matter disposed of by cremation, so as not to become a source of danger in the present and in the future.

As said before, in the mere matter of street lighting we are ahead of the Romans; but that does not necessarily imply that we have any reason to feel particularly proud of the progress made in the two thousand years, as long as the old fashioned lamp-posts and the still worse looking electric light posts, carrying their death-dealing wires, are allowed to disfigure our streets, we will have ample scope for improving the condition of things. As to parks, the necessity of which has at last been realized in our most progressive cities, we still have a good deal to learn from the old Romans. San Francisco, New York, Rochester, and many more cities have made suitable provision that plenty of breathing places shall be left in their centers. Wide streets, admitting the possibility of rapid transit and of the construction of special rapid transit lines must be planned, to prevent that congestion from which Rome suffered. I am glad to see that work in this direction is progressing more rapidly in America than elsewhere, though as Mr. Clark says:

"The history of rapid transit is a doleful one in each case, because the demand for more has arisen so much more rapidly than it was furnished, at least in American cities. In Europe the effect has been to crowd the people into the middle of a city; the effect here in America is to enable them to live in the fresh air of the suburban districts, where they sometimes have room even for a small garden."

The 19th century, as far as the opportunity of the masses for bathing is concerned, seems strongly inclined to Seneca's belief, but I hail gladly the evidence of such a decadence as is shown by the establishment of free, or nominally free public baths in many of the cities of the Continent and England, and also in some American cities. The New York Association for Improving the Condition of the Poor, has erected a public bath capable of providing nearly one thousand baths daily. "These are fitted up" Mr. Patton says, "with every facility for bathing in comfort and with all possible sanitary precautions, following the plan so successfully tried in Vienna. Most of the baths are supplied with warm showers or sprays so

that every impurity is immediately carried away and any risk of infection is absolutely removed. For the same reason the towels will be steamed after use and the cake of soap given to each bather will not again be used in the baths. A charge of five cents will be made for each bath, including the use of a clean towel and a cake of soap. But tickets will be given on the most favorable terms to institutions, societies, churches, and donors to the Association's funds, so that the advantages of the baths may be wide-spread and extended."

I think I have shown you fully by this time that the problems of municipal engineering which confront us are of supreme importance to you all as human beings and as taxpayers. I have sketched the solution of some of them as carried out in a sister republic thousands of years ago, but recognizing a changed condition of things, though the problems remain the same, you may well ask, what are we going to do about it? How are these problems to be solved in our day? To my mind the question at once becomes the larger one of municipal government, and that such it undoubtably is, is shown by the action of some of our most progressive American cities, foremost of which I might mention St. Louis, a town conspicuous for the honesty, efficiency and technical ability shown in the administration of its departments, notably that of public works. Time is too short for me to go into a discussion of the revised charter of the city of St. Louis. Those interested will find plenty of food for thought in Mr. Moor's admirable paper on this subject in the Journal of the Association of Engineering Societies for March 1892. A few general considerations, however, may well be in place.

In almost all municipal governments the money spent annually for improvement along the lines indicated is far in excess of that spent for other purposes. The problems themselves, as you will admit, are weighty ones. They should be given the most careful consideration. The planning of all works should be done by men competent to foresee the needs of the city in the future. The work itself when carried out should stand as a monument to the ability of the designer, the honesty of the builder, and last, but not least, the intelligence of the community, and right here, I think, ladies and gentlemen, lies the main difficulty. It may be a bitter pill to swallow, but if any community, in this republican commonwealth at least, fails to solve successfully for itself these weighty problems, it has only itself to blame. Ability to design a system of water

works, of sewers, to lay out a park, or build a public building, does not go with the profession of a Republican or Democratic faith. If a competent Democratic engineer plans an admirable system of sewers, and the construction falls into the hands of an incompetent Republican successor, or vice versa, what profits it the city? Yet instances of this kind are not impossible. Is there any rhyme or reason in calling a man to a position requiring professional ability, and then ousting him with the next turn of the political wheel? If under such conditions men of ability are found occupying some of our municipal offices it is something devoutly to be grateful for, but no thanks are due to the system. If ever a community should be on the lookout as to the fitness of the men to whom it proposes to confide its offices of trust, it should be as regards the fitness of the men to whom it proposes to confide the carrying out of its public works, to whom it confides its public health. But too often the opinion seems to prevail that because Tom, Dick or Harry is a good hand to run the political machine he must be a good man to place in charge of a modern high-duty pumping engine, or that a man who is known to have sold his vote is implicitly to be trusted when placed as inspector on some public work. Such are not the methods of political administration by which these weighty problems are to be solved.

The community at large, we, the citizens, must recognize two things, that national politics must be swept out of municipal affairs, and that a good thing costs and is worth money. The moment the first point is fully recognized the attention of every community will be directed toward finding the best man, and it will often find him in its midst, for filling the responsible position of director of municipal works, of city engineer. Such a man once secured, the community, if it be an intelligent one, and I hope the day is not far distant when all our communities may be classed under this head, will continue to retain his services as long as it can. Vide again the example of St. Louis, and its relation to Col. Flad. I said that almost every community would be likely to find a competent man, or body of men, in its midst to take charge of its municipal works, but believe me they are not the men who put themselves forward. They are men who allow their work to speak for themselves, and whom the office must seek. Men with the ability needed for planning such works, and the honesty for carrying them out for the best interests of the taxpayers, have self respect, a vital obstacle for securing an office which is only too often considered, when it does exist, a share of the political spoils.

The second point, the one of expense, is almost as vital as the first ; for if you put a good man in a place, then tie his hands, and do not furnish him the money for carrying into effect his plans, you can readily make his administration a failure. The policy that those public works are the best which cost the least is a mistaken one, though I confess it has been the prevailing one in most of our cities. Those *good* public works are the best which cost the least. Letting contracts to the lowest bidder often results in under-cutting legitimate prices and profits to such an extent that the contractor must cover himself by scamping his work under a dishonest inspector, or doing a losing job. Generally the former is the case. Instances are numerous, and the cities in which they occur are only following a penny wise and pound foolish policy.

California is called "Our Italy." We glory in the fact. Perhaps it behooves us all the more then to profit by the experience of our sister community in the old world. I have shown you the far and short-sightedness of the Romans in their municipal administration. Do not let it be said a thousand years from now that we no more than the older cities of the Continent knew how to profit by the past. Building on a virgin soil, in a congenial climate, our cities still in an embryonic state, let us plan for their development with the welfare of those who come after us at heart. Let us give them wide, beautiful streets shaded by trees, spacious parks, pure water, public baths, effective sewerage. If we but solve these problems well, future generations will rise up and call us blessed.

DISCUSSION.

MR. MARSDEN MANSON.—"Mr. President : The experience in examining some of our municipal works is new, and in some respects interesting. Some of it would not last as many months as the Roman works have lasted centuries. We have seen large sewers built in such a way that it would be easier to pull out a brick on the sides or bottom than it would be to pick up one of these chairs and turn it around. There are many miles of sewers in this condition. In fact, where the specifications state that the bottom of the sewers should be laid dry, they have been construed, either from ignorance or design, to mean that the bricks should be laid *in* there dry. In sewers where there are two layers of bricks (generally one layer when the inspector is not around) up on the sides, for eight or

twelve inches, the bricks are laid in dry, and then mortar is used on the rest of the sides and on top. In a few of the sewers we do not find the joints filled with mortar at all.

Very large quantities of fine cement are imported here, but we never hear of any of it getting damaged. We know a great deal of it is damaged at sea in transportation. This is ground in our fine quartz milling machinery and re-barreled. I have known of such instances. In such cases it saves a good deal of time and trouble not to test the cement, and it appears to be in the original packages.

There are one or two points in Professor Marx's paper that interest me very much. I do not remember whether the exact grades of the Roman sewers were given. I call to mind seeing a few years ago a few specimens of the material used in the construction of roads and public works generally. I was struck with the strength of the mortar and the size of the stones. I would like to ask Professor Marx if the paper refers to grades and size of material?"

PROFESSOR MARX.—"It does not."

MR. MANSON.—"It is an exceedingly interesting paper, and I am very anxious to see it published. I propose to put a marked copy of it in the hands of each one of our supervisors at the earliest moment, and write upon it for their benefit a scriptural quotation: 'read, learn, mark, and digest what is herein.'"

PROFESSOR FRANK SOULÉ.—"I want to say a word in regard to quality of the cement used in some of the Roman sewers. Parts of sewers that can now be seen were laid in ordinary rubble masonry, and some in brick with Roman cement, and after the lapse of centuries the bricks are worn away and the cement stands up like saw teeth all along the line. I wish we could construct our sewers in San Francisco with cement that had something of that quality. Of course the general quality of the masonry in these Roman constructions is above criticism almost. We can still see the remains of the ancient roads. They run straight over the hills and down into the valleys, and though for centuries they have been unused and uncared for, they are just as solid and strong, apparently, as when first constructed. I do not know why we should not have as good constructions here. I think Professor Marx has sounded the keynote in the song of praise we shall sing when our municipal affairs are correctly administered in this respect, namely, the proper selection of engineers, officers, and constructors in municipal work.

In some of the cities not far from here I have had the pleasure of taking part in a movement to overthrow the present condition of

things. I am not making a political speech when I state that the non-partisan idea of the government of the cities, which is a growing sentiment at the present time, is to select men for positions for their value and worth, and not on account of their national party affiliations. Men composing the board of public works, the city engineer, and the surveyor, should be selected for their knowledge, ability and character, and not for their connections with one party or another. I think the time will come when such a policy will be pursued, and when such officers will be retained in office for long terms, regardless of the success or failure of any one political party. For instance, the judges of our Supreme Court hold office, I believe, for twelve years, and I see no reason why engineers in charge of important public works should not hold office as long. When the ideas of Professor Marx are carried out in our cities, there will be a great change for the better in all respects."

MR. RANDELL HUNT.—"I would like to say a few words in regard to this paper. It seems to me the idea is not exactly correct when we lay the blame upon the community for selecting political men and not technical men to take charge of public works. I do not think the fault lies entirely with the community, but in a large measure with the engineers themselves. We are all engineers here, and I think I may speak freely. Many engineers in this country who are pushing themselves forward to take charge of these works are only half educated men, and those who are educated and have genuine ability as engineers, are apparently marks of envy among their own kin. In order to put public works into the hands of men who are engineers, there must be a standard of education and ability. Until engineers themselves recognize that standard, and place themselves upon a high professional footing, the public at large never can and never will have very much respect for them. Several communities in this country have been mentioned which show some exceptions, but I think they simply prove what I am trying to make plain: that in a community of distinguished engineers, and many of them with high regards for themselves, they have forced upon their surroundings a proper regard for them as engineers, and have been taken up by the community in that way. Professor Marx has mentioned St. Louis. I do not know of a better example in the Union. That city has been the nucleus of a band of noble and able engineers for a great many years, and they have made their influence felt not only in St. Louis, but all over the United States.

I see no reason why a Democratic engineer following a Republican engineer every four, or six, or eight, or twelve years, should not be able to carry on the work as well as his predecessor."

PRESIDENT GRUNSKY.—"What I have to say is somewhat supplementary to the remarks of Professor Soulé, and to those just made by Mr. Hunt. There is sometimes difficulty in securing competent engineering control of public works not due to the lack of qualified engineers, but due to a defect in the system of municipal government. To illustrate this, it may be well to review briefly the conditions under which our municipal governments are operating at the present time in this State. In most cases responsibility is divided. It is made the duty of the city engineer to plan street and sewer work, but he is not ordinarily permitted to supervise these works during construction; this falls upon the superintendent of streets, who also has charge of the maintenance of the streets, the sewers, and other municipal works; he is also inspector of material, but he is rarely a technical man; he has no professional reputation at stake. In fact, the law does not contemplate or require intelligent engineering supervision.

Where special charters provide for the appointment of boards of public works, the administration is generally somewhat improved, and there is better opportunity of putting the construction of public works in charge of engineers. But when work is superintended by some politician who depends upon party politics to put him in power, qualification for the position is rarely asked for, yet it is as necessary to have intelligent engineering supervision of construction as to have the work properly designed."

MR. RICHARDS.—"I differ from my friend Mr. Hunt about the amount of technical ability that enters into the construction of sewers. I am inclined to think that to construct good sewers it requires about nine-tenths honesty. I do not think that the construction of sewers is a very difficult matter even for an engineer of ordinary capacity. It is not a question of competency, it is a question of honesty."

PROFESSOR FRANK SOULÉ.—"I think Mr. Hunt's remarks would apply with force to the employment of engineers on works owned by corporations, rich companies, and men who had it within their own individual powers to make selection of engineers, but when it comes to a municipality it is a different question entirely. Those who appoint the engineers, apparently, are chosen at a popular election; they may make a good selection or a poor one, it depends

upon the exigencies of politics and upon the particular individuals who are elected to office."

MR. RANDELL HUNT.—"I thought I had expressed myself with very much clearness, but it would appear that I have not. My remarks were intended in an entirely different way from which they have been taken. I meant to say that engineers must proclaim a higher standard for themselves, and make themselves recognized in the community. I am not trying in any way to bring the matter home to the locality in which we are living, but to insist that *everywhere* throughout the United States the engineers should maintain a certain standard, and cause the people to understand that only engineers of ability should have charge of the water works, the sewers, and the streets.

I am endeavoring to make the point that we as engineers must establish such a plane and put ourselves there. I mean to say that a man who drags a chain one year, and runs a level the following year, should not be called an *engineer*. The community would not call him one if we did not. There is no other calling that does not have some standard to base its profession upon. If it is not a legal standard, it is one that is promulgated by the profession itself. No man can practice law unless he has completed a certain amount of study. No man can practice medicine unless he has taken a certain course of study and passed the examinations. It is so even with the preacher. If we would get at the root of the whole evil of incompetent engineers filling municipal positions, we must have a standard for engineers to build upon. I did not allude to sewers in my former remarks in any way, but I was taken to task about them by my friend Mr. Richards. I must disagree with him on that point."

MR. RICHARDS.—"I want to add one word only. The complaints which we hear all over our land in regard to municipal works do not pertain, as far as I have read, to want of skill on the part of those who performed the work, but it is want of carrying it out according to the plans that are plain and easily understood; it lies in the execution of the work. As Professor Marx has pointed out, it lies in the executive administration. Mr. Hunt, no doubt, is quite correct as to a recognized standard in the engineering profession."

MR. G. F. ALLARDT.—"I admit that the difficulty in properly carrying out municipal work is partly on account of legal matters. Contractors are obliged to give heavy bonds to faithfully carry out the work. This is overlooked by the inspectors or engineers either

for personal reasons, or perhaps, from dishonest motives, and I would suggest that we make a movement to change the municipal law in regard to public works to the extent that not only shall the contractors give bonds, but that the engineers in charge shall also do so for the faithful performance of the work. Perhaps then we will have better work done."

MR. F. GUTZKOW.—"If a contractor were asked in our presence to express his opinion on this question, he would probably reply that it was all quite true, but as he is working in a San Francisco style and not a Roman style, and is paid five dollars a running foot, he would probably desire to ascertain how it would be possible at the price allowed him to make his work as substantial as the Romans did theirs. There are not many rich contractors — not many millionaires among them. If the property holders in a community were willing to pay ten dollars a foot for constructing a sewer, they then might expect one that would approach the Roman standard. But as long as we do not pay more liberally we will never get it."

MR. ALLARDT.—"We must 'do as the Romans do'."

MR. MANSON.—"Our friend, Mr. Richards, has made an exceedingly good point in saying that it needs nine-tenths honesty to produce good work. There is no question about its being a very necessary element not only in engineering, but in all work. But if we get a small percentage of politics mixed in, it ruins the best mortar, it softens the best bricks, it spoils the best concrete, and you can't make the work homogeneous to save your life. Then another matter that is terribly injurious is the man with a 'pull'. He is the worst creature that you can have about where there is a piece of work to be done honestly and thoroughly; you will generally find that he has some interest in common with the poor contractor that prevents the work from coming up to the requirements of the specifications."

MR. RANDELL HUNT.—"A great deal has been said about cement and mortar, and Professor Marx has called attention particularly to the fine engineering work in St. Louis. I would like to inform those members of the Society who are not aware of the fact, that nearly all public works in that part of the country are constructed with natural American cement, which is very much inferior to the Portland cement. It depends not so much upon the cement as upon the person who uses it."

MR. BRIDGES.—"Professor Marx did not say anything about the Chicago sewerage. I presume he must know, as you all do, that the sewerage for the World's Fair Grounds at Chicago is probably the most perfect system that the world has ever seen. And the Chicago people today are letting one contract of five million dollars to take the sewerage in a canal out into the country. Certainly Chicago is equal to St. Louis in engineering ability. Chicago has had such men as William J. McAlpin at the head of public works. Chicago has commenced to build two cribs out in the lake and is making two tunnels under the lake for the purpose of getting a supply of excellent water taken from the bottom four or five miles out.

Mr. Hunt wants a high plane for the profession. Engineers have the advantage in their own hands; the way to be an engineer is to accomplish something and to do it well; to do it so that no one can find fault with it. When I stood in St. Peters and saw what Michael Angelo had done, and saw the art displayed in St. Paul's, I felt that it was the work of genius, the names of those constructors will go down to the end of the world. And so it will be with every engineer who does his work well."

PROFESSOR MARX.—"I did not refer to the work in Chicago, because, if I remember rightly, at a meeting of the Western Society of Engineers, it was represented that there had been some scamp work done there. I do not now remember all the facts. I did not cite a number of cases, because that would take too long, I only desired to illustrate my position. No attempt was made to bring in everything that had been done in sanitary engineering since the founding of Rome."

MR. G. W. DICKIE.—"There has been a good deal said tonight on the subject of inspectors and contractors. I suggest that we devote an evening to the subject of 'Ethics Governing the Relationship of Contractors and Inspecting Engineers'."

REGULAR MEETING, APRIL 7th, 1893.

PROCEEDINGS.

MINUTES.

The meeting was called to order by the President, C. E. Grunsky.

The minutes of the last regular meeting were read and approved.

The following gentlemen were elected to membership.

For Members :

Thomas H. Leggett, Mining Engineer.....Bodie, Cal.

P. E. Lear, Electrical Engineer.....San Francisco, Cal.

For Junior :

John J. Williams, Topographer.....Berkeley, Cal.

The following names were proposed and referred to the Executive Committee :

For Members :

Curtis M. Barker, Civil Engineer, of Mayfield, Cal.; proposed by Joseph C. Sala, A. H. Sanborn and M. M. O'Shaughnessy.

Geo. C. Power, Civil Engineer, San Buenaventura, Cal.; proposed by P. J. Flynn, C. H. Congdon and Otto von Geldern.

Valentine J. Rowan, Civil Engineer, Los Angeles, Cal.; proposed by P. J. Flynn, W. H. Davenport and Otto von Geldern.

Professor Charles D. Marx, of the Leland Stanford, Jr., University, delivered an address before the Society entitled "Some Problems in Municipal Engineering," which was discussed at length by Messrs. Manson, Soulé, Hunt, Richards and others.

Mr. Dickie suggested that the relation of *contractor* and *inspector* on engineering works be made the subject of a topical question, to be discussed at some future meeting.

The Electrical Society extended an invitation to the members of the Technical Society to attend the meetings of that organization,

which are held regularly on the first and third Mondays of each month in room 55, 819 Market Street.

The President referred to the visit of the Technical Society to the large gasometer of the San Francisco Gas Light Co., on March 11, and to the courtesies received at the hands of Mr. Crockett, by whom the invitation had been extended, for which he desired to express the appreciation of the Society.

Mr. Richards stated that an invitation was extended by Mr. Adolph Sutro to the members, to hold an informal meeting at Sutro Heights on some Saturday in the near future. The President designated Mr. Richards to act in coöperation with the Secretary, in order to make the necessary arrangements for such a visit. The members are to be notified in due time of the plan and the day.

Adjourned. OTTO VON GELDERN, *Sec'y.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME X. No. 4.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

ELECTRIC TRANSMISSION OF POWER LONG DISTANCES.

POSSIBILITIES AND LIMITATIONS AFFECTING ITS SUCCESSFUL AND ECONOMIC EMPLOYMENT.

BY W. F. C. HASSON, Mem. Tech. Soc.

[Read May 5th, 1893]

The following paper is in no sense purely technical, but is only a formulated reply to the questions —

What distance may power be transmitted?

What is the efficiency of the transmission?

What is the cost of transmission?

During the past few weeks a number of technical and general papers on this subject have appeared in electrical journals. These articles, though full of interest to those connected with electrical pursuits, have not been of such a nature as to be of much assistance to the practical purchaser.

This latter has little interest in the methods by which the end is attained, the important points to him being the cost of installation, operation, and maintenance of the machinery, the efficiency of the transmission, and the distance that it may be successfully accomplished. After a brief historical review, and a statement of the systems now being commercially perfected to meet the requirements of

long-distance transmission, we will investigate the relation that exists between cost and efficiency for a given distance of transmission, and especially consider how the cost is affected by certain electrical considerations.

In April, 1887, a paper entitled "The Transmission of Power by Means of Electricity" was read before this Society by its author, N. S. Keith. The paper was comprehensive historically, and correct technically, and not only demonstrated the underlying principles governing electric transmission, but also prophesied its early consummation. Mr. Keith indicated advance in the line of continuous current motors and generators, and at that time it was generally believed that this system would finally be developed to meet all possible requirements.

Although the fundamental principles of the dynamo were certainly known to Faraday as early as 1831, and crude methods of commutation were used the following year, it was not until 1867 that Dr. Werner Siemens described a machine that has a definite connection with the present machine of commerce, and which led to the name "Dynamo-electric-machinery."

The commutator, being perfected, made possible the "direct" or "continuous" current, and a variety of generators were devised.

The possibility of reversing the "generator" or "dynamo," as it is generally called, and utilizing it as a "motor" was definitely recognized in 1873. Since then the advance in methods of construction, systems of regulation, etc., has been great and in many lines, and dynamos and motors of many types have reached a high state of efficiency. The advance was so rapid that it certainly seemed possible that methods of insulation would be so perfected as to render possible the employment of continuous currents of any desired electro motive force.

So many difficulties appeared in the way of making satisfactory alternating-current motors, that the attention of successful electricians was directed almost entirely to the perfection of those operated by the continuous current. The high cost of fuel in many possible mining and manufacturing districts, promised a large field for the employment of electric machinery, at least in cases where water power was within reasonable distance. Notwithstanding this demand, the advance of power transmission machinery by no means kept pace with that of electrical machines for other purposes.

Continuous current machinery was soon brought to a high state of efficiency and regulation, and furnished a perfectly satisfactory method of transmitting power, limited distances where low electro motive force might be economically employed. As the relations between electro motive force and strength of current and their connection with the *amount* of power generated were better understood, it became evident, that unless high E. M. F. was employed, the cost of copper would practically prohibit the transmission of power long distances. The continuous current has strong advocates who do not hesitate to say that large amounts of power may be successfully commutated and distributed at an electro motive force of 5,000 or 6,000 volts. However, the large corporations that manufacture electrical machinery have not sustained the confidence of the public in these statements by furnishing commercial machines constructed on these lines. In fact, the company that has actively opposed the use of alternating current machinery, now states that, in the present state of electrical science, there is a definite limit to safe commutation far below that required, and that if an attempt is made to generate heavy continuous currents at such high voltages, the machines will inevitably break down.

So broad a statement, concerning the final perfection of any electrical system, may today be accepted with a fair amount of doubt. So firm is the belief of this particular company, however, that during the past year it has brought to a state of commercial perfection an alternating current system.

Notwithstanding the difficulties, certain able enthusiasts, notably Nikola Tesla, have devoted their entire time to the perfecting of commercial, alternating current motor systems.

The transmission of power, for lighting purposes only, may be accomplished by means of any of the commercial alternating current systems. The generators furnish an electro motive force sufficiently high to allow an economic distribution of power over several miles. By means of transformers, an electro motive force of 10,000 volts is easily obtained for transmission long distances to the point of distribution, where reducing transformers supply a safe pressure for local circuits. The success of this system is evidenced at San Antonio, Cal., where a transmission of 28 miles at 10,000 volts is now in operation.

The electrical manufacturing companies of America have been so engrossed in developing and exploiting their lighting and

railway systems, that they have apparently in the past given little serious attention to the perfection of systems to meet the needs of electric power on the Pacific Coast, and they have given still less consideration to the circumstances which render its employment possible.

These, briefly stated, are —

1. A vast mountain range, extending the entire length of the coast, where the accumulation of the winter snow creates a great and constant supply of water power under high heads.
2. A country full of mineral resources.
3. A country where manufacturing industries are still in their infancy.
4. A country practically devoid of coal.
*5. That, in the vicinity of many paying mines, the forests have been destroyed, and the cost of transporting fuel renders the operating of the mines unprofitable.
6. That in many cases available water power is within reasonable distance of these mines.
7. That power exists within distances ranging from ten to forty miles of many fairly large towns, where it may be profitably utilized for supplying lights, the operation of electric railways, and the furnishing mills with power.
8. That the further development of water power for the generation of electric power will not only build new manufacturing cities, but the distribution of the water will make fertile large tracts of land.

During the past year, however, the question of long distance transmission has been extensively discussed, and the best energies of the electrical companies have been devoted to its satisfactory solution.

The result is that three alternating current systems in various stages of commercial perfection are now before the public. These are:

1. The single-phase, or popularly called synchronous system.
2. The two-phase or di-phase system.
3. The three-phase or tri-phase system.

The first of these systems has been commercially perfected to meet certain requirements. It is admirably adapted to the transmis-

*In a plant that will shortly be in operation for transmitting power 13 miles, the total cost of electric and hydraulic machinery, together with their erection, will be less than $40,000, and the annual saving in fuel will be $20,000.

sion of power that is to be used for the continuous operation of motors of not less than thirty horse power. Its success has been exemplified in the machinery that has now been in operation almost two years at Telluride, Colorado. Machinery for the transmission of power thirteen miles to operate the mills of the Standard Consolidated Mining Co. is now being installed at Bodie, Cal.

The single-phase motors are not self starting, and hence there are many circumstances that they do not easily meet. Self-starting non-synchronous motors are promised to the public, but until this promise is realized the field of this system is limited.

The second and third systems, comprised in the term multiphase, are more comprehensive, and undertake to furnish power for multifarious purposes as follows :

1. The direct operation of incandescent lights.
2. The operation of ordinary arc-light machines by self-starting motors.
3. The operation of alternating current arc lights under certain conditions.
4. The operation of continuous current arc lights from rotary transformers.
5. By means of rotary transformers to furnish continuous current for the operation of the ordinary railway motors.
6. The operation of self-starting stationary motors of all powers, ranging from one eighth to five hundred horse power.

The fulfillment of these promises will certainly meet all demands.

The promoters of these two systems each claim great individual advantages, but, until they have been submitted to the test of commercial operation, the only claims that may be admitted are that the three-phase system requires less copper wire for transmission, and that the two-phase is somewhat more simple and better adapted to meet the possibility of a perfected single-phase motor.

Within three months a three-phase plant for the transmission of 300 horse power will be in operation at Redlands, Cal. Within less than a year one of these systems will be installed for the transmission of three thousand horse power twenty miles, under the guarantee that it will meet requirements for all varieties of power, and that the efficiency of transmission from generator axle to point of distribution will be at least 79 per cent.

Whatever system is adopted, the cost of generators and motors will not vary greatly, and the important factor in a long distance

transmission is the amount of copper necessary for the line. In order to understand how this amount may be varied; it will be necessary to have a clear comprehension of two or three electrical terms.

The electric power transmitted over a line is measured in *volts* and *amperes.*

The *pressure* or *intensity* or *electro motive force* of the current is measured in *volts.*

The *current* or *quantity* that flows is measured in *amperes.*

The number of *volts* being multiplied by the number of *amperes* we obtain the number of *watts* of power. 746 *watts* are equivalent to one mechanical horse power.

Analogous to this is the method of measuring water power.

To measure water power we must know the *quantity* of water, and also the *head* or *pressure* under which that *quantity* of water is obtained.

The amount of power is found by multiplying the *quantity* that flows in pounds per minute by the *head* or *fall* of water. This result will be in *foot pounds* and is easily expressed in *horse power.*

The greater the *head* the less the *weight* of water required to produce a given power.

Similarity with electricity: the greater the *volts* the less the *amperes* necessary for a given power.

To proceed with the analogy: If the *head* of water remains constant, and it is desired to transmit a greater power, the *quantity* of water must be increased, and the pipe conducting it must be correspondingly increased.

Similarly: If the *electro motive force* or number of *volts* remains the same, and it is desired to transmit greater power, the *quantity* of electricity must be increased. In other words, the number of *amperes* must be increased, and the size of copper wire increased accordingly.

Again returning to water: Having a given quantity of water so situated that it becomes necessary to carry it a long distance through pipes in order to get a certain head, the size of pipe must be increased in order to lessen the loss of head due to friction. In other words, the greater the distance the greater the loss of head, the larger the pipe the less the loss of head.

Similarly: In the transmission of electricity there is a loss of electro motive force due to the resistance offered by the wire, and the original pressure being the same, but the distance being increased, the

size of wire must be increased if the same efficiency is to be preserved.

Again: If a certain quantity of water is supplied under a given head to a horizontal pipe from which there is no leakage, the amount flowing past any section of the pipe in unit time is the same. Also as the distance from the source of power increases there is an increasing loss of head or pressure.

Thus in order to transmit increased power, and still have a certain head of water at the end of the pipe, either the original head or size of pipe must be increased.

Similarly: If a certain quantity of electricity under a given electro motive force is supplied to a long line of copper the current will be the same in each part of the circuit, but the electro motive force decreases as the distance from the generator increases.

In order to transmit increased power and retain the same electro motive force at the end of the line, either the original electro motive force or the size of wire must be increased.

We must not deceive ourselves by thinking that we may reason further concerning the transmission of electric power by its similarity to that of water power. The laws governing the two are entirely different, and at best there is but an analogy which we may use for illustration only.

The complete analogy may be expressed as follows:

The *size of pipe* necessary to conduct a given water power *increases* with the *quantity* of water, the *distance* and *efficiency* of transmission, and *decreases* with the *pressure*.

The *size of wire* necessary to transmit a given electrical power *increases* with the *quantity* of current, the *distance* and *efficiency* of transmission, and *decreases* with the *electro motive force*.

In order to show how the amount of necessary copper may be varied, I have compiled the following tables which give the weight and cost of copper necessary to transmit a *single horse power various distances* with *varying line losses* when the initial electro motive force *varies* from 500 to 20,000 volts.

In these tables the transmitting line only is considered, and no attention is paid to the efficiency of generators, motors, or the transformers that would be necessary for the transmission of the higher electro motive forces.

To determine the cost copper is taken at a uniform price of sixteen and two thirds cents per pound. This is above the market price today, but it is a safe figure and sufficiently accurate for the purposes of comparison.

TABLE 1.

FIVE-MILE TRANSMISSION.

Distance, Miles.	Initial E. M. F.	Final E. M. F.	Line Loss, Per Cent.	Pounds of Copper per H. P. Delivered.	Cost of Copper per H. P. Delivered.
5	555	500	10	2398	$399.00
5	588	500	15	1510	251.00
5	625	500	20	1066	177.00
5	1110	1000	10	600	100.00
5	1176	1000	15	375	62.00
5	1250	1000	20	266	44.00
5	2220	2000	10	150	25.00
5	2352	2000	15	93	15.50
5	2500	2000	20	66	11.00
5	3330	3000	10	66	11.00
5	3528	3000	15	42	7.00
5	3750	3000	20	30	5.00

TABLE 2.

TEN-MILE TRANSMISSION.

Distance, Miles.	Initial E. M. F.	Final E. M. F.	Line Loss, Per Cent.	Pounds of Copper per H. P. Delivered.	Cost of copper per H. P. Delivered.
10	588	500	15	6040	$1006.00
10	625	500	20	4264	711.00
10	1176	1000	15	1510	251.00
10	1250	1000	20	1066	177.00
10	2220	2000	10	600	100.00
10	2352	2000	15	375	62.00
10	2500	2000	20	266	44.00
10	3330	3000	10	266	44.00
10	3528	3000	15	168	28.00
10	3750	3000	20	118	19.00
10	4440	4000	10	150	25.00
10	4700	4000	15	93	15.50
10	5000	4000	20	66	11.06

TABLE 3.

FIFTEEN-MILE TRANSMISSION.

Distance, Miles.	Initial E. M. F.	Final E. M. F.	Line Loss, Per Cent.	Pounds of Copper per H. P. Delivered.	Cost of Copper per H. P. Delivered.
15	588	500	15	13590	$2265.00
15	625	500	20	9590	1599.00
15	1176	1000	15	3395	566.00
15	1225	1000	20	2398	399.00
15	2220	2000	10	1350	225.00
15	2352	2000	15	849	141.00
15	2500	2000	20	600	100.00
15	3330	3000	10	600	100.00
15	3528	3000	15	375	62.00
15	3750	3000	20	266	44.00
15	4440	4000	10	337	56.00
15	4700	4000	15	212	35.00
15	5000	4000	20	150	25.00

TABLE 4.

TRANSMISSION AT 10,000 VOLTS INITIAL E. M. F.

Distance, Miles.	Initial E. M. F.	Final E. M. F.	Line Loss, Per Cent.	Pounds of Copper per H. P. Delivered.	Cost of Copper per H. P. Delivered.
20	10000	9000	10	118	$19.60
20	10000	8500	15	84	14.00
20	10000	8000	20	67	11.10
25	10000	9000	10	185	31.00
25	10000	8500	15	130	21.60
25	10000	8000	20	104	17.30
25	10000	7500	25	89	15.00
30	10000	9000	10	266	44.30
30	10000	8500	15	188	31.30
30	10000	8000	20	150	25.00
30	10000	7500	25	128	21.30
30	10000	7000	30	114	19.00
35	10000	9000	10	363	60.50
35	10000	8500	15	256	42.60
35	10000	8000	20	204	34.00
35	10000	7500	25	174	29.00
35	10000	7000	30	155	26.00
35	10000	6500	35	143	24.00
40	10000	9000	10	473	79.00
40	10000	8500	15	334	55.60
40	10000	8000	20	266	44.30
40	10000	7500	25	229	38.00
40	10000	7000	30	204	34.00
40	10000	6500	35	188	31.30
40	10000	6000	40	178	29.60

TABLE 5.

TRANSMISSION AT 20,000 VOLTS INITIAL E. M. F.

Distance, Miles.	Initial E. M. F.	Final E. M. F.	Line Loss, Per Cent.	Pounds of Copper per H. P. Delivered.	Cost of Copper per H. P. Delivered.
20	20000	18000	10	30	$5.00
20	20000	17000	15	21	3.50
20	20000	16000	20	17	2.83
25	20000	18000	10	46	7.66
25	20000	17000	15	33	5.50
25	20000	16000	20	26	4.30
25	20000	15000	25	22	3.60
30	20000	18000	10	66	11.00
30	20000	17000	15	47	7.80
30	20000	16000	20	37	6.25
30	20000	15000	25	32	5.30
30	20000	14000	30	29	4.80
35	20000	18000	10	91	15.10
35	20000	17000	15	64	10.60
35	20000	16000	20	51	8.50
35	20000	15000	25	43	7.10
35	20000	14000	30	39	6.50
35	20000	13000	35	36	6.00
40	20000	18000	10	118	19.60
40	20000	17000	15	84	14.00
40	20000	16000	20	66	11.00
40	20000	15000	25	57	9.50
40	20000	14000	30	51	8.50
40	20000	13000	35	47	7.80
40	20000	12000	40	44	7.30

TABLE 6.

TRANSMISSION OF THE OUTPUT OF A 500 KW. GENERATOR.

E. M. F. Motor.	E. M. F. Generator.	Line Loss.	Efficient Output Motor.	Efficiency Generator Axle to Motor Axle.	Pounds of Copper Wire to Transmit.			
Volts.	Volts.	%	H. P.	%	5 Miles.	10 Miles.	15 Miles.	20 Miles.
1000	1111	10	554.8	76.2	361,574	1,446,295	3,254,164	5,785,180
2000	2222	10	554.8	76.2	90,394	361,574	813,541	1,446,295
3000	3333	10	554.8	76.2	40,175	160,699	361,574	642,789
4000	4444	10	554.8	76.2	22,599	90,394	203,385	361,574
1000	1176	15	523.9	72.	215,010	860,040	1,935,090	3,440,160
2000	2352	15	523.9	72.	53,752	215,010	483,772	860,040
3000	3528	15	523.9	72.	23,779	95,960	215,010	382,240
4000	4704	15	525.9	72.	13,444	53,752	120,943	215,010
1000	1250	20	493.1	67.7	142,844	571,376	1,285,596	2,285,504
2000	2500	20	493.1	67.7	35,711	142,844	321,399	571,376
3000	3750	20	493.1	67.7	15,871	63,486	142,844	253,944
4000	5000	20	493.1	67.7	8,928	35,711	80,349	142,844
1000	1333	25	462.3	63.5	100,437	401,748	903,934	1,606,992
2000	2666	25	462.3	63.5	25,109	100,437	225,983	401,748
3000	4000	25	462.3	63.5	11,159	44,638	100,437	178,554
1000	1428	30	431.5	59.3	72,910	291,639	656,190	1,166,556
2000	2856	30	431.5	59.3	18,227	72,910	164,047	291,639
3000	4285	30	431.5	59.3	8,101	32,404	72,910	129,617

NOTE.—In estimating the efficiency of transmission from generator axle to motor axle the efficiency of the machines is taken as 92 per cent.

500 KW. is approximately equal to 670 horse power.

These tabulated figures appear very interesting, and I regret that they are not absolutely true. They are correct as regards the passage of a continuous current over a perfectly taut two-wire line in a country where small variations of temperature occur. In calculating them no attention has been given to the effects due to static capacity, nor to self and mutual induction in long transmission lines.

Other points to be considered, are — Standard sizes of wire; safe current carrying capacity of wires; necessary sag in the line; limits to stable construction.

The corrections due to these considerations will depend upon the system adopted and the amount of power to be transmitted. Their effect will be similar on the data given, and the tables are sufficiently accurate for purposes of comparison and general estimates. Each electric transmission is a problem by itself, and in order to be successful must be solved in accordance with the rules of good engineering practice.

In determining the feasibility of utilizing water power to operate electrically the industries of any particular town or city, careful consideration must be given of the following points, viz.:

1. The amount of water power permanently available.
2. The cost of developing this power.
3. The interest on this amount.
4. The total demand for power.
5. The amounts and relative locations of the various kinds of power.
6. The cost of steam plants now in operation.
7. The interest on this amount.
8. Cost of fuel for plants now in operation.
9. Cost of operating present plants. Labor.
10. Cost of maintenance of present plants.
11. The amounts and kinds of electric power already in operation.
12. The distance of transmission.
13. The estimated cost of the hydraulic machinery.
14. The guaranteed efficiency and regulation of the hydraulic machinery.
15. Estimated cost of electric machinery.
16. Estimated cost of line construction.
17. Total cost of operating hydraulic and electric machinery.
18. Total cost of maintenance of hydraulic and electric plants.

19. The interest on the total estimated cost of proposed plant.
20. The estimated gross income.

For further information on the many points to be considered in this connection, I refer you to the articles by Messrs. C. L. Bradley and L. B. Stillwell, and Doctors Louis Bell and C. E. Emery, lately published in the electrical journals.

Undoubtedly, cheap power is essential to the development of the latent industries of California. It is equally true that the reliable electrical manufacturing companies are now prepared to furnish machinery to provide cheap power. The only difficulty in the way of advance appears to be a lack of confidence on the part of possible purchasers. This lack of confidence appears to be due to their inability to reconcile the conflicting claims and statements made by the electrical companies concerning their own machinery and that of competing companies.

Many transmissions that are easily possible, are by no means feasible.

No long-distance-transmission is absolutely impossible, although it may be thoroughly impracticable.

DISCUSSION.

THE PRESIDENT.—"We have with us this evening, Mr. Geo. P. Low, the President of the California Electrical Society, and we will be pleased to have him open the discussion."

MR. LOW.—"It is with hesitation, as a stranger to the deliberations of the Technical Society, that I open the discussion of a paper so thoughtfully prepared as the one we have just heard. Although I have one or two questions to ask, I will preface them with a few statements.

The members of this Society may not be fully aware that in the United States, the Pacific Coast has been foremost in transmitting electric power long distances. The first long distance transmission in this country was that between Oregon City and Portland. There an alternating current is transmitted at a pressure of 4,000 volts, thirteen miles. However, the power is used for lighting purposes only. Then came the power transmission plant at Telluride, Colorado, which has been referred to by the speaker this evening. Following that came the plant at San Antonio, from which power for

lighting purposes is transmitted at 10,000 volts, fifteen miles to Pomona, and thirty miles to San Bernardino. During the past month I have had the privilege of examining the details of this plant.

A most interesting installation is now under construction at Redlands. It is a tri-phase system to be used for both lighting and power. The operation of these two plants in Southern California is watched with great interest by the electrical world. But to eclipse them in magnitude is another installation about to be constructed for the transmission of 3,000 horse power a distance of eighteen or twenty miles, and to which Mr. Hasson has referred.

In an installation of this kind, many perplexing things arise that would completely nonplus a layman. In the San Antonio plant for instance, conditions arise that will for a time baffle any electrical engineer.

I will not weary you with relating the several most interesting phenomena that came under my observation in examining the installation at Pomona. I will mention only one, which is known as the Ferranti effect.

Those who are conversant with hydraulics can readily realize if we have a pipe line with a head of water of 400 or 500 feet, that the pressure at the foot of that pipe line is greater when the end is closed than when it is open, naturally you would expect that the moment the water commenced to flow through the pipe the pressure at the lower end would drop. This is erroneous when applied to the San Antonio plant. As stated by the speaker, the potential is 10,000 volts, the current is sent from the plant in San Antonio to San Bernardino, a distance of 29.7 miles. Naturally you would suppose that the potential at San Bernardino would be less than at the dynamo, just as the pressure drops in hydraulics. Instead there is an increase of about ten per cent., and in place of having, say, 9,000 volts on the line, they have 9,900 volts.

This is a very interesting matter which I thought best to call your attention to, as it illustrates one of the many unexpected things that arise in electrical engineering. It would be interesting if Mr. Hasson would give us a plausible explanation of the Ferranti effect.

I recognize that these tables are at least the result of considerable mathematical work, and I would like to ask for my own information, and possibly that of others, the formula from which they are computed. This is essentially a matter of copper computation,

and it would be interesting to know just how the figures are derived."

MR. HASSON.—"I will reply to Mr. Low's questions at the close of the discussion."

PROFESSOR SOULÉ.—"Have broad thin bands of metal instead of round wire been used for the transmission of electricity?"

MR. HASSON.—"Not on a very extensive scale."

PROFESSOR SOULÉ.—"It is supposed, is it not, that for transmission purposes the surface is more effective than the cross section?"

MR. HASSON.—"I will take up that matter in discussing the Ferranti effect."

PROFESSOR SOULÉ.—"Have the electricians succeeded in Europe in transmitting a strong current through a long line? I have read that this had been done for a distance of forty miles or more."

MR. HASSON.—"Power has been transmitted 108 miles, and a great many difficulties have been encountered. The transmission was successful for the time being. It was for experimental purposes only, at the Frankfort Exposition. Experiments were made with an electro motive force as high as 25,000 volts."

PROFESSOR H. B. GALE.—"There is a question which I believe has not been touched upon in the paper this evening, but on which I would like to hear some discussion, as it seems to me an important one to consider at the outset in designing a power-transmission plant for general purposes — that is the different distribution of power throughout the day at the points of generation and consumption. In a city where power is used for various purposes, the amount used varies greatly at different times of the day. In the winter-time lighting would begin about half past four, and for an hour or more power would be required for all kinds of uses. In some portions of the night the amount needed would be less than one half what it is at other times, and during the twenty-four hours the average consumption would not be more than one half of the maximum.

It has been very clearly set forth in the paper before us, that one of the chief items to be considered is the cost of copper for the line, and this item, among others, is affected by the point that I wish to raise. If we could generate and transmit over the line continuously the average amount of power consumed during the day, and have some means by which the excess for part of the hours could be stored at the point of consumption and delivered at the time it is needed, it would cut down by one half the cost of wire

for transmission, reduce one half the cost of the hydraulic and electric plant at the source of power, and also do away with any difficulty that may be experienced in regulating the hydraulic motors, which is sometimes considerable in small plants where the load changes very quickly. Then again, if we could transmit in this way, the hydraulic motors, generators, and transformers could always work at the point of greatest effciency, and thus the water would be economized, and the greatest possible effect realized from a given supply.

This, of course, can be done by storage batteries at the point of consumption, which would receive the surplus power when the supply was greater than the demand, and store it up, to be used again during that portion of the day when the need was above the average.

Of course, we would have to consider whether the cost of the storage battery plant would outweigh the cost of a generating and transmitting plant able to furnish the maximum amount of power at any time. Again, in many cases, if we do not store electricity at the distributing station, we must, in order to fully utilize the power at our command, have reservoirs for storing water at the generating station, and the cost of these alone would sometimes exceed that of the batteries. This point is an interesting one, and frequently may have an important bearing upon the commercial profit to be derived from power transmission."

MR. H. VISCHER.—"By these tables I am led to infer that the loss is not dependent upon any one of the three different systems that may be employed. These figures are general, are they not?"

MR. HASSON.—"The figures are calculated for a two-wire system, and the only element that is considered is the ohmic resistance presented by the copper. As I have stated, they must be corrected to meet the circumstances of the system adopted. It would be very difficult to tabulate in a simple form figures that would meet all conditions."

MR. VISCHER.—"What would be the effect if a line were installed for one system and another system was employed?"

MR. HASSON.—"The line might not fit. There are two, three, and four-wire systems. Suppose a line installed for a three-wire, two-phase system. Two of the wires would be of the same size, and the third would be larger. It would be rather difficult to adapt this line economically to a single-phase or a three-phase system. The difference in the amount of copper alone might vary over 10 per cent."

MR. VISCHER.—"There are certain limits, inside of which the conditions will fluctuate, no matter what the improvements may be, so far as can be foreseen?"

MR. HASSON.—"Beyond a doubt that is true. The weight of wire given would be safe for any system. The total amount, however, would be divided up differently to meet the circumstances of the various systems. As I have stated, for equal efficiencies, the three-phase system requires less wire than the two-phase or single-phase. In order to be perfect and economic from an engineering standpoint, all the circumstances of the proposed transmission must be known, and, the best system being adopted, the plant designed in its entirety."

THE PRESIDENT.—"Mr. Hasson, the Society would like a little more information in regard to the transformers that have been spoken of. I think a little light thrown on their use, and the method of converting the high potential to a low one would be interesting."

MR. GEO. W. DICKIE.—"I would like to ask why a transformer transforms?"

MR. HASSON.—"I will take up all the questions in an irregular order:

Concerning the use of copper ribbons instead of round wire, leaving electrical effects out of consideration, round wire has for the purpose of stable construction sufficient advantage over the flat ribbon to render the use of the latter impracticable.

Concerning Mr. Gale's remarks with regard to the average amount of power required, and the amount required for various purposes during different periods of the day. This is one of the most important considerations in all power transmissions, and apparently the one comprehended with the utmost difficulty by the commercial man. If a company contemplates the construction of a railroad, one of the first steps is to have a preliminary survey, from which they will be able to form some idea of the cost of construction, and also the value of the road after it is built.

It has been my experience that the men contemplating installing electric plants for the transmission of power long distances want at once an estimate of the cost of the electric machinery independent of the purposes for which the power is to be utilized. In almost all cases the total demand for power greatly exceeds the average demand, and in cases where a continuous current only is required, the storage battery, in its magnified and perfected form, will doubtlessly play an

important part. In view, however, of perfected alternating current distributing systems for all purposes, the value of the storage battery becomes at least questionable.

The ratio of the minimum water power available to the maximum power required would be an important factor in this matter.

Mr. Low asks for the formula from which these tables for weight of wire have been calculated. The results may be obtained from the ordinary formula for the size of wire necessary to carry a given current with a given loss of electro motive force. The formula I have used is:

$$W = \frac{D^2}{E^2}\ HP.\ \frac{(100 - L)}{L}\ 266.5$$

Where W is the weight of copper wire in pounds.

D, the distance in miles.

E, the E. M. F. at the motor in hundreds of volts.

$HP.$, the horse power delivered to the motor.

L, the per cent. of line loss represented in units.

Thus to transmit 200 horse power ten miles with 10 per cent. loss, and have 3,000 volts at the motor, we have

$$W = \frac{10 \times 10}{30 \times 30} \times 200 \times \frac{(100 - 10)}{10} \times 266.5 = 53{,}300 \text{ lbs.}$$

I have stated in the paper the other circumstances taken into consideration in the preparation of the tables.

I will further state that Table 6 is calculated to meet the requirements of a single-phase synchronous system where the maximum E. M. F. of the generator is 5,000 volts, and that of the motor 4,000 volts. If a three-wire two-phase system is adopted, a certain reduction in the weight of wire may be made, and a still further reduction may be made in a three-wire tri-phase system. The other questions become more technical, and it is difficult to answer them clearly, and at the same time briefly.

The modern dynamo is so constructed that copper wires are made to pass normally through the lines of force that exist in the vicinity of a magnetic field. There is a definite resistance to the passage of the wire, and it requires mechanical energy to overcome this resistance. The result is that work is done, and mechanical energy is transformed electrical energy. As the wire approaches the magnetic field, the current starts flowing in one direction in it. The intensity and amount of current both start from zero and gradually

increase to a maximum, then gradually decrease to zero, then the current starts in the opposite direction, increases to a maximum, and finally returns to zero. That is, the intensity of the E. M. F., and the quantity of current, may be represented by a wave line, and alternately positive and negative impulses of electric power are imparted to the copper wire.

By suitable commutating devices all of these impulses are thrown in one direction as the current is taken away from the machine. As the impulses are made with great rapidity, thousands per minute, the interval between them becomes infinitesimal, and the wavy line of power becomes practically straight, and we have the *continuous current.*

Now the product of the ordinate representing the intensity of electro motive force by that representing the strength of current at the same instant gives the amount of electric power. That is, volts multiplied by amperes give watts.

The complete cycle from zero to positive maximum, then to negative maximum, is called a phase. The current curve and the E. M. F. curve are not necessarily together in phase, one may lag behind the other. We may say that it is the electro motive force that pushes the current along. It is the various resistances in the wire that cause the current to lag behind the E. M. F. in phase. We may bring about such a difference in phase that although there is an impressed E. M. F., and a current flowing, we find no power being delivered at the end of the line. This is known as the wattless current, and is a very unhappy current to the engineers perfecting long-distance transmission machinery.

It is generally understood that with continuous currents the conducting power of a wire is directly proportional to the area of its cross section. When alternating systems were first installed many perplexing phenomena occurred. The practical drop in the electro motive force did not agree with the theoretical one. This difference was found to increase with the electro motive force, and the rapidity of the alternations.

In answer to Professor Soulé's question : It is definitely recognized that flat ribbons offer less resistance to the passage of an alternating current than equal cross section of copper in a circular form. When a current is started in a wire there is a definite obstruction to its passage. As the alternating current is reversed with great rapidity this effect becomes very marked. It is called *self induction*, and it varies with the diameter of the wire, the length

of the circuit, the strength of the current, the square of the number of alternations, and certain other considerations.

When two or more electrical circuits are parallel, the current passing in each circuit creates a magnetic field in the vicinity of that circuit that has a definite effect on the parallel circuits. This effect is known as *mutual induction*, and is of serious importance in the construction of long-distance transmission lines. This effect increases with the length of the line and the strength of current, and varies directly as the number of alternations. Long lines of copper wire also have a definite capacity, and may retain a static charge of electricity.

It would be impossible at this time to go into these questions in further detail, and I only refer to these effects in order that I may more clearly explain the Ferranti effect referred to by Mr. Low. Several explanations of this effect have been given. The most simple is the following:

(Illustrating by diagram.) If the line OX represents in intensity and phase the impressed electro motive force, and OY represents in intensity and phase the electro motive force due to self induction, then OZ the diagonal of the parallelogram, $OXZY$ will represent the value of the resultant electro motive force.

It is evident that the value of OZ will depend on the angle between OX and OY. If this angle is obtuse, OZ will be less than OX; if the angle is acute OZ will be greater than OX.

The self-induced E. M. F. is 90 degrees in phase behind the current. In ordinary circuits the current and E. M. F. are practically alike in phase. Thus the angle XOY becomes equal to angle XOZ, plus 90 degrees, and hence is obtuse, and OZ is less than OX as we ordinarily find it. If, however, such circumstances may be created that the current is in advance of the resultant E. M. F., then the angle XOY becomes 90 degrees minus the angle between the current and impressed E. M. F., and hence is acute, and OZ is greater than OX.

By using a condenser in an alternating-current circuit the current may be thrown considerably ahead of the electro motive force in phase; in a long line carrying a high potential current the line itself has considerable capacity and acts as a condenser, hence the above circumstances are created, and the Ferranti effect follows. A detailed explanation of this is given by Mr. Charles Steinmetz in a late number of the *Electrical World*. Although there is an increase in the E. M. F., there is no gain in power, as the displacement of

the current phase more than overbalances the rise in electro motive force."

MR. VISCHER.—"Is it the invariable practice to use wire of the same size for all portions of the line?

MR. HASSON.—"The wire should be uniform in size until a point is reached where some of the power is taken off the line. Although there is a fall in potential the quantity of current remains the same, and the size of the wire depends on both of these factors."

"MR. LOW.—"Replying to the question, 'why does a transformer transform?' which Mr. Hasson has evidently overlooked: Assuming that we are all conversant with a dynamo, and with the method by which it generates a current, we have there only two conditions which we need to consider. First, a magnetic field; second, a wire cutting that field.

The magnetic field is fixed, and may be considered as rigid and immovable. The wire passes through it, and the actual cutting of the magnetic field by the wire generates electricity.

Considering the transformer as a dynamo, what have we there? An iron core; about that, a primary coil of wire through which passes a current of electricity. This will magnetize the iron core, and about it will exist a magnetic field of a certain polarity. If we reverse the magnetic field we will reverse the magnetic polarity of the core. This reversal of magnetic polarity occurs very rapidly when an alternating current is sent through the primary coil.

We have, in addition to the primary coil, a secondary coil which is fixed and immovable. Consequently, instead of, as in the dynamo, cutting the magnetism with the moving wire, we cut a fixed secondary wire with a moving magnetism. In short, in the dynamo, a moving wire cuts a magnetic field; in the transformer, a moving magnetic field cuts a fixed wire. Whatever number of wires we place in this magnetic field, the effect in each one will be the same, and by properly designing the secondary coil, we may obtain any ratio we please between the electro motive force of the primary and secondary coils."

MR. DICKIE.—"This subject has not yet come to the point that is interesting to me. I would like to know something about the cost. Given a certain locality and a certain water power, and a certain use for that power; and given another locality and another certain power required. How will they compare, and what will be the outlay to transmit that power with a given per cent. of loss?

Also, how will that compare with the capitalized cost of steam at the same point?"

MR. HASSON.—"At the close of the paper I have read this evening are twenty itemized statements of the points that must be considered in order to arrive at any intelligent results in replying to Mr. Dickie's question. The question is too complicated to allow the formulating of a general reply to it. I can refer you to a paper recently read by Dr. Chas. Emery, before the American Institute of Electrical Engineers. This paper and its discussion contain much interesting and valuable information on this subject."

MR. DICKIE.—"I have read these papers, and to my mind they are entirely inapplicable to our conditions here. I would like to have an estimate of a transmission on the lines I have indicated."

MR. HASSON.—"You are right in stating that the figures are deduced from circumstances different from those existing here. I could give you an estimate of the relative cost of steam and electric power. However, it would require more time than we have at our disposal, and as the calculations would be based on imaginary conditions the results would be wrong, and in all probability misleading. During the past year I have made estimates on a great variety of transmissions, and the results vary widely. I reiterate, many transmissions are possible electrically that are not feasible financially.

I may say that this matter has been gone into very thoroughly in the proposed Folsom-Sacramento transmission. The result is that an electric plant will be in operation within a year to supply a vast power for a great variety of purposes in Sacramento. I regret that I am not at liberty to give you the figures in this case."

PHOTOGRAPHIC TOPOGRAPHY.

By Ernest McCullough, C. E., Mem. Tech. Soc.

[Read May 5, 1893.]

The object of this paper is to present a method of surveying which will be a valuable auxiliary to plane-table and stadia work, and in some cases is extremely useful alone. It is by no means new, but is not very well known, and its advantages are so great that engineers who have much topographic surveying to do should understand it.

The principle depends upon the art of projecting perspective views upon a horizontal plane, and was first used by French naval officers in the beginning of this century in the survey of coast lines. Perspective drawings were made of certain places from two or more positions, and sextant angles taken to several objects in the landscape, and the angles recorded on the drawings. These drawings were afterwards used in the mapping of the shore line, and the accuracy of the work depended upon the skill with which the sketches were made.

The invention of photography made it possible to do better work, and Colonel Laussedat of the French army made experiments covering a period of years to perfect the system. He published a work on the subject in 1865, and no improvements have been made since, unless multitudinous patents for cameras can be styled improvements.

The system is extensively used in Europe, and is very little known in this country, where, of all places, one would think it most valuable from an economical standpoint.

Instances can be given of the time in which various surveys have been made by this method, but such records are of no use unless the ground were known, but the French engineers generally consider that a topographical survey and map, when a camera with horizontal and vertical circles is used, can be made in one third the time required by other methods.

Any camera may be used provided it is perfectly level when the view is taken, and the smallest size adapted for the work is one with a

5 × 8-inch plate. Smaller cameras may be used in the same manner as a sketching pad, to carry away unimportant details, but are of little practical use unless most excellently made. All lenses must be good. Although an ordinary camera may be used, still it is better to have one for the purpose, provided with two levels on top at right angles, and four leveling screws beneath. The box should be solid, and focusing done by means of the objective slide. If the camera has a compass, or a horizontal limb, and a vertical limb, so that up or down sights may be taken, it will be complete.

Glass negatives are the most accurate to use, but paper negatives on account of portability are more convenient. The weight of the glass in the field is a drawback.

There are several adjustments of the camera which must not be neglected. The first is called "the test for register." The film on the sensitive plate must exactly replace the surface of the ground glass. To do this set the instrument up and focus for a distant view. Make a scratch to show the relative positions of the plate

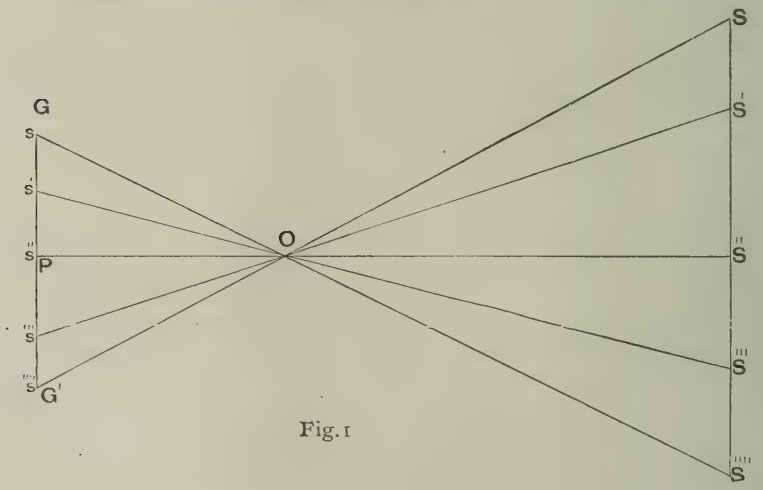

Fig. 1

and tube. Take out the ground glass, and put in one with a transparent film. Focus on this, and make another mark. In actual work this difference must be allowed for by changing the focus after the removal of the ground glass, so the film on the plate will be in the right position. The instrument maker should see to the register, but it is as well to test his work.

As everything depends upon the focal distance this must be accurately determined. Lens makers usually state the focal distance,

but as it is liable to vary, the operator had better determine it himself. For simple convex lens, double or plano convex lens, measure from optic center to surface of ground glass. For double compound lenses proceed as follows: (Fig. 1.)

Set up several stakes in the ground distant from O about two or three hundred feet as $S\ S'\ S''\ S'''\ S''''$. With transit at O, measure angles $S\ O\ S''$, etc. Set up the camera at O, level it carefully, make the image S'' coincide with a vertical line through the center of the plate, and photograph the stakes. The greater the distance apart on the plate of the stakes the more accurate will be the determination of the focal length. $G\ G'$ represents the plate, $O\ P$ the focal length. Measure $s''\ s''''$ on plate, then

$$O\ P = \frac{s''\ s''''}{\text{tan. a}} = s''\ s''''\ \text{cot. a}$$

$$S\ O\ S'' = \text{a}$$

For a test of distortion of the lens, with $O\ P$ just found, compute the angles $S\ O\ S'\ S\ O\ S''$, etc., and if they agree with angles taken with the transit the lens is free from distortion.

Next, the horizon of the view must be found. Find the center of the ground glass and draw a vertical and horizontal line through it. Level the instrument carefully, and set beside it an engineer's level, with the telescope at same height as the lens of the camera. With the level find some object in the distance. Turn the camera to this object and move the object slide up and down until the object is exactly at the intersection of the lines on the ground glass, the object slide is then in its normal position, and a scratch on the slide will determine that position for all time. This scratch should be marked zero, and graduations should extend above and below it. The lower graduations should have a minus sign before their numbers. The plate holder should have four fine needles, so inserted in the frame that their shadows will be photographed. When the picture is developed, lines scratched on the plate and connecting these points will occupy the same positions as the lines drawn on the ground glass. The maker can fix these needles in place.

The horizontal line represents the horizon of the picture, and is the trace of a line on a level with the center of the instrument. The object of graduating the vertical movement of the object slide is to provide for a changing of the horizon when necessary to limit sky views. By noting the number on this index when the view is taken, the actual horizon of the picture is set off from the horizon of the instrument when plotting.

One more adjustment and we are done. This is to measure the field of view. Half the length of the plate, divided by the focal length gives the tangent of half the horizontal angle. The horizontal angle is the field of view we require, and dividing 360° by this angle, gives us the number of views needed to go around the circle.

Half the width of the plate, divided by the focal length, gives us the tangent of half the vertical angle. As a general proposition it may be stated that the greater the focal length, the smaller the field of view and the greater the accuracy in the work. The smaller the focal length, the greater the field of view, greater rapidity (because fewer views) and less accuracy.

To take a view, set up the camera and level it carefully. Adjust to focal length and set the object slide to the most favorable position and note index number for fixing horizon in views. Then adjust the stop, set in the plate holder and verify the levelling. The levels are apt to get a little out during all the handling. When all is ready, take the picture.

THE PLOTTING.

In the test for distortion, the whole idea of the method for using the proof is given. The proofs are conical projections, and the optic center the point of view. The objects represented are so far distant that their images are formed on the same focal plane, and the point of sight remains constant as in perspective drawing.

On the plate draw the horizontal line (the horizon) and the vertical line, from the shadows of the points of the needles. If the objective was above or below the horizon, then instead of drawing it, draw a line parallel to it above or below, as indicated by the index number observed. From the vertical line measure to the right or left to the object you wish to locate, and divide this distance by the focal length, this will give the tangent of the horizontal angle from the line of sight. From the horizontal line, which is a trace of the plane of the optic center, measure up or down, as the case may be, to the object, and divide this distance by the focal length to obtain the tangent of the vertical angle.

Every point located on the map must show in two views at least. These views are taken from points previously fixed by triangulation or by direct measurement. The points from which the views are taken, must be plotted, and from these points lines drawn on the bearings given in the field notes when the view was taken. On

these bearings lay off the focal distance. and at the end of this line draw one at right angles to represent the plate. On the line representing the plate, lay off on either side the distances from the vertical to the object, and from the point of view draw lines through these points. The lines through two plates produced to an intersection, locate the objects.

Figure 2 illustrates well the method of plotting. *O O'* represent the points from which the views were taken. *G G'* and *G'' G'''* the plates, *O P* and *O' P'* the line of direction of sight. *A B C* etc. and *A' B' C'* etc. represent on the plate the objects to be located and their positions on the maps are shown by the points of intersection.

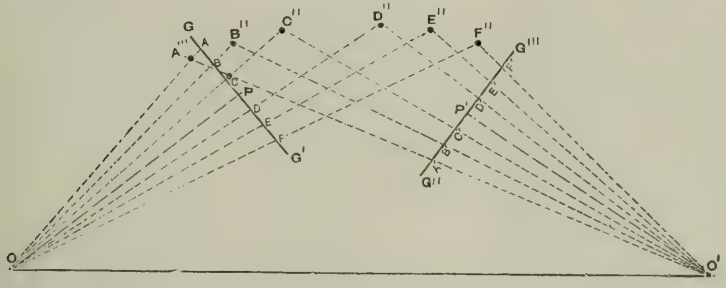

Fig.2

To fix the elevation, measure the distance from point of sight to object, and multiply into tangent of vertical angle already found; add to the elevation of the point from which the sight was taken, the height of instrument, and add or subtract, according to whether the point is above or below the horizon, the height above ascertained. This will give the elevation of the object above datum.

Spherical aberration does not interfere with the accuracy of the work, provided the focal length is ascertained by means of a point near the extremity of the plate in the horizon. (See Fig. 1.)

FIELD WORK.

The field work may be performed in one of three ways, or a combination of all.

1. The ground may be triangulated with the transit and views taken from the triangulation points with the camera, the direction of the views to be ascertained by azimuths from the lines between

stations. These azimuths to be taken by a compass, or by means of a horizontal limb.

2. The camera may be used in connection with a pocket compass, the work starting from a measured base.

3. The work may be done with a camera alone, fitted with a compass, horizontal limb, and vertical circle. In this case the triangulation is carried on with the work. With ordinary care, either method is good. The camera must be rigid and the plate truly vertical.

Below is a form of record.

Station.	View.			Remainder.
	Number.	Index Number.	Bearing.	
A.....	1	0	195½°	
	2	0	227°	
B.....	1	— 2	84°	

The index number may be the same or different for all views at the same station. Any time of the year is good for this work, and any hour of the day when the air is clear. Long distances between stations should be chosen as short bases increase error. A few views only are necessary, as sketches may be made of unimportant places, and these views should be well chosen. A little care exercised in selecting positions will save much office work.

OFFICE WORK.

Upon the scale used depends the accuracy of the plotting. If the scale is large then very long sights should not be attempted, but if the scale is small then of course the range can be longer. The error in height is in proportion to the distance, and Professor Hardy says that with a focal length of 1.64 feet this error will not exceed one foot in 550 yards. Colonel Laussedat has shown that with a scale of $\frac{1}{3000}$ with a focal length of 0.5 m. points, 1,500 meters distant, may be represented, and with a scale of $\frac{1}{5000}$ the operations could be conducted at 4,000 meters.

When the plates are prepared for plotting the office notes are placed in a book in seven columns as follows :

FORM OF RECORD TO REDUCE HT. TO COMMON DATUM.

View.	Distance.	Point.	Ref. ft.	Ref. of Sta. ft.	True Elev. ft.	Remarks.
Va.		1	+102	+460	+562	
		2	+ 90		550	
		3	− 25		435	

The first column is for the views.

The second column contains the distances to the points.

The third column the names or numbers of the points.

The fourth column the height above or below station.

The fifth column elevation of station.

The sixth column elevation of point.

The seventh columns for remarks.

For drawing in contours, the fixing of natural and artificial objects on the plan, with their heights noted, will give all the data necessary together with a close inspection of the proofs as the work proceeds. In the case of a bare country, with no buildings, fences or trees, a few painted stakes or flags put in at salient points will serve.

It is best to work directly from the negatives as the paper positives are too much affected by atmospheric changes. Blue prints are as easy to work from as silver prints if positives are used.

Surveying by camera has equal advantages with surveying by plane-table as it is a graphic process, but it is more exact than the plane table as atmospheric changes have no effect on the records. It is more rapid in the field work, and is accurate for more than one scale in the plotted work.

As compared with transit and stadia it is more rapid in the field, and a little quicker in the office. Like it, the records may be kept, and reproduced at any time to different scales, and it has a further advantage in that all errors of observation are entirely eliminated. Various plans for saving labor in the office work have been suggested, but this paper is already long enough.

Before closing, attention should be called to one point, namely, that the notes may be sent to a draughtsman who never was on the work, and a correct map may be drawn by him. No other method approaches it in this particular.

The literature on this subject in French and German is very

extensive, but the following works in English are very good if any one desires to study the subject farther.

Photography Applied to Surveying, by Lieut. Henry T. Reed, U. S. A.

The Topographer, His Methods and Instruments, by Professor Haupt (latest edition).

Topographical Surveying, in No. 72, Van Nostrand's Science Series.

REGULAR MEETING, MAY 5th, 1893.

PROCEEDINGS.

MINUTES.

The meeting was called to order at 8:30 P. M. by President C. E. Grunsky.

The minutes of the last regular meeting were read and approved.

The following gentlemen, having been balloted for, were declared duly elected members of the Society.

Curtis M. Barker, Civil Engineer.....Mayfield, Cal.
Geo. C. Power, Civil Engineer.....San Buenaventura, Cal.
Valentine J. Rowan, Civil Engineer.....Los Angeles, Cal.

The following name was proposed and referred to the Executive Committee. For Member:

George P. Low, Electrical Engineer, San Francisco; proposed by W. F. C. Hasson, N. S. Keith, and A. Lietz.

Mr. W. F. C. Hasson then read a paper entitled "Electric Transmission of Power Long Distances," discussing the possibilities and limitations affecting its successful and economic employment. The subsequent discussion was opened by Mr. Geo. P. Low, President of the California Electrical Society, followed by Professors Gale and Soulé, and Messrs. Vischer, Dickie and others. Lieutenant J. N. Jordan, and A. W. Stahl, U. S. Navy, were invited to partake in the discussion, which was closed by a demonstration of various principles involved in the consideration of the subject by the author.

Mr. Ernest McCullough then read a paper on the subject of "Photographic Topography," which was illustrated on the black board, and explained by showing the practical methods of working with a camera.

The President stated that the California Medical Society, through its directors, had met the directors of the Technical Society, and that certain arrangements had been made that may lead to a joint meeting of the two societies in the near future. The proposed

meeting has for its object the discussion of certain sanitary conditions of California cities and towns, from a medical as well as from a technical standpoint.

The Secretary called attention to the courteous invitation extended by Mr. Adolph Sutro to the members, to hold an informal meeting at Sutro Heights. In a letter, written to Mr. Richards, Mr. Sutro named Saturday, May 13, as a suitable day. The invitation was accepted for that day, and the Secretary instructed to notify the members, and to request them to inform the Society at an early date of their intention to attend.

Adjourned.

INFORMAL MEETING, MAY 13th, 1893.

About thirty members of the Society meet at SUTRO HEIGHTS at 10 A. M., where they were kindly received by Mr. Sutro, who extended every courtesy to make the visit an entertaining and most pleasant one. A particular point of interest was the extensive bathing establishment now in course of construction near the ocean beach, to which the members were escorted for an inspection of every technical detail.

A bountiful luncheon was served subsequently. A number of appropriate speeches were made at the table, the President expressing the appreciation of the Society to the host in well-chosen remarks.

The meeting adjourned at 4 P. M.

OTTO VON GELDERN, *Sec'y.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME X.· NO. 5.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

ARE CALIFORNIA HOMES AS HEALTHFUL AS THEY SHOULD BE?

BY MARSDEN MANSON, C. E.; Ph. D., Mem. Tech. Soc.

[Read May 19, 1893.]

This question must be answered in the negative, for the prevalence of filth diseases* in city, village, and country homes in California, in the presence of natural conditions which are a guarantee of the purest health, forces the conclusion that we are not maintaining the healthful conditions which naturally exist. There is, therefore, every justification for a rigid inquiry into the causes which produce and propagate filth diseases, and the use of plain words in laying the facts bare. The threatened visitation of that most frightful of all filth diseases, Asiatic cholera, further accentuates the propriety of bringing up the subject of cleanliness—not only as to person—but

*The writer prefers the term *filth disease* to the more frequently used term *zymotic disease*. The former more plainly expresses the true cause of much sickness, which, when fully appreciated, suggests the proper remedy — cleanliness.

in the broader and equally important application to water, food, air, and surroundings.

The causes and conditions which propagate many filth diseases have been considered so subtle that an investigation of them is oft-times regarded as super-technical and impracticable until too late, when their track is plainly marked in the health reports and death list. The simple and rigorous methods of analysis which microbiology brings to the aid of chemistry, makes the detection of the cause and course of filth diseases absolutely certain.

The particular microörganisms which produce certain of these diseases are as well known as are the symptoms; they are traced from patient to patient through the water, food, or clothing with a certainty, which if generally known, would make every intelligent human being an expert in sanitation. They are multiplied in favorable places and under favorable conditions with a degreee of rapidity which would poison a continent in a few weeks with the developments of a single germ. It is therefore necessary to discuss these facts in plain words, and to bring them not only before the physician and the civil engineer, but to the very children in the school house. The complete following up of the study thus inaugurated involves one of the deepest problems of modern science, namely, how to treat small areas so as to permit them to be densely populated without impairing the natural healthfulness, and even to remove natural conditions inimical to healthful occupation.

All the sewers, all the water works, all the heating and ventilating contrivances ever built, have been attempts, more or less successful, to solve this great problem or to remove the fatal consequences of failing to provide proper sanitation at the outset. It therefore becomes necessary for municipal officers to employ the most honest means and the highest talent in planning and constructing every detail of municipal engineering, and to leave no part to the charge of either the ignorant or the grasping. Such large portions of the population of all cities are either ignorant or unmindful of their surroundings that special efforts must be made to force sanitation upon them; not only for themselves, but for the sake of those who are forced to partake of the consequences of witless or vicious self-neglect.

THE CONDITIONS IN THE COUNTRY.

The duties of the writer have called him to many parts of the State, and the natural conditions have been a matter of close obser-

vation and study for many years. It may be said that no filth disease naturally prevails in California, except chills and fever in certain low lands in the great valley, and in similar localities elsewhere. Yet in these localities the disease is easily escaped by avoiding the use of surface water. This fact was first brought to the writer's notice some fifteen years ago by Colonel Mendell of the Engineer Corps, of the U. S. A., and has since been closely followed up and observed in numerous localities.

In travelling through the great valley of California, the close observer is frequently struck with the entire absence of chills and fever in a particular locality of a district over which the disease is generally prevalent, the drainage and surroundings of the escaping locality being frequently worse than the infected neighborhood. The method of ascertaining the conditions is as instructive a way of explaining the facts as any other — After the usual salutations and inquiries as to weather and crops, the subjoined questions and answers follow —

"What kind of water have you?"

"Well water."

"Deep well?"

"No, not very, some twenty feet, struck a fair flow at sixteen feet."

"Is the water good?"

"Firstrate, soft water, washes easy, so the women folks say."

"Any chills and fever?"

"Well, a little now and then towards fall, but we generally go up to the mountains or to the seashore for a time and get over them."

"What causes the chills?"

"Well the air draws in here from the tules and swamps and brings malaria."

Passing on for a mile or less the inquirer reaches a neighbor and asks the same questions of a sturdy citizen whose ruddy youngsters and buxom wife bespeak entire absence from chills. His replies as to water are about as follows —

"Our well is pretty deep, we did'nt get much water at the first gravel and had to bore 190 feet (frequently three or four hundred feet) before we got water, but then got a good flow rising nearly to the surface."

"What kind of water?"

"Firstrate cool water, but a little hard and mineral like. The women folks have to use soda in washing."

"Any chills and fever?"

"No, not here, but down at neighbor Blank's they have a touch in the fall."

"Why do you escape?"

"Well the air draws in here from the plains and we don't get the miasma from the tules."

These questions the writer has asked dozens of times and found that where chills and fever prevail, the wells are either shallow, or the surface water is permitted to drain in alongside the well casing and is pumped up with the deep water.*

In country homes, exposed tanks badly cleaned are another source of injurious contamination. Very frequent cases are found of milch cows and stock being watered from a shallow well surrounded by the accumulated filth and manure of years. The milk or flesh of such animals cannot possibly be wholesome.

The City of Stockton affords a very marked example of the effect of the water supply upon chills and fever. In the earlier history of the city the water was obtained from wells, generally shallow. After the introduction of the water from deep wells, the disease began to disappear, and is now as rare as it was formerly prevalent. A study of the various strata is very instructive in this connection. At from 40 to 60 feet a stratum of dense clay occurs, below which the water is drawn from very distant sources, at from fifteen hundred to twenty six hundred feet the water is hot and charged with light carburetted hydrogen which largely forms the natural gas of the locality.

The disposition of garbage, manure and fæcal matter around country homes rarely receives that attention which health necessitates. The dangerous and fetid cesspool is almost universal. It could be easily replaced by the construction of a closet on a well shedded mound and the use of a little dry earth. With ordinary attention this simple expedient makes the surroundings entirely pure and inodorous. Some such simple method should be obligatory in isolated country school houses and hotels.

THE CONDITIONS IN VILLAGES.

The villages and small towns of California where there is a public water supply, are generally furnished from deep wells supplemented by the wells of individuals. These latter are classified as

*See "Drinking Water as a Source of Malaria," the *Sanitarian*, August, 1892, Vol. XXIX, Page 127.

are country wells, and are subject to greater danger of surface contamination from cesspools and garbage heaps. The mountain towns and villages have generally a water supply of great purity. It is in the villages and small towns that the disposition of fæcal matter reaches its maximum point of danger to health and life. This fact is distinctly recorded in outbreaks of diphtheria, typhoid, and gastric fevers, and other filth diseases—which diseases could find no lodgment were the naturally healthful conditions maintained by the adoption of proper measures.

The most glaring case of contamination of this character which ever came under the writer's notice was as follows: Some five years since, in looking into the sanitary conditions of a valley town, one family in particular was reported as suffering from a series of filth diseases necessitating expensive doctor's and druggist's bills and frequent trips to the seashore. The head of the house had been very positive and strong in his condemnation of the healthfulness of the town, and was then absent and his home tenantless. The case was so aggravated that there was justification for a very thorough examination of the premises. The house-drainage was at first looked to. There were no waterclosets, tubs, nor basins, so that danger from this source did not exist. The kitchen sink, receiving all waste water and refuse matter from this source, drained into an open box very much clogged up and full of putrescent matter. This box passed within a few feet of the well casing and was broken so as to permit the drainage to pass to the well; within less than twenty feet of the well was a cesspool with the putrifying fæcal matter of years soaking through the soil in all directions.

The strong remarks of the owner as to the town were but feeble expressions compared with a proper condemnation of this individual case. Instructions were left to the effect that if pure water were not supplied, the household could dispense with the doctor and druggist and send for the undertaker. It is needless to state that as soon as the causes and actual conditions were pointed out the matter was promptly remedied.

The City of Sacramento is particularly exposed to the pollution of the soil from cesspools. This danger is increased by the drainage of water closets into the cesspool, which practice is essentially more dangerous than the simple pit, although both should be avoided.

An illustration of the results of the want of care as to purity of water supply, is very strikingly illustrated in the case of Plymouth,

Pa. This town has about eight thousand inhabitants. In the spring of 1885, nearly one person in every six was stricken with typhoid fever, more than ten per cent. of the cases being fatal, the deaths being about 130. This outbreak was traced by Doctor Shakespeare to a single case occurring during the winter in the water shed supplying part of the town. The dejecta of this patient were thrown out upon the snow and upon the occurrence of warm weather the germs found their way into the water supply with the above result. The melting of the snow occurred on the 25th of March ; the disease broke out on the 10th of April, and was confined to that portion of the inhabitants using water from the infected source.* Medical and sanitary journals and reports are full of many similar cases.

In the hotels and public schools in the villages and smaller towns without proper sewerage systems the closets are generally of the most primitive kind, and foul to a nauseating degree. The simple measures suggested for country homes would make a marked difference in the health of those exposed to this source of disease. It must be remembered that where improper methods of disposing of human waste are practiced the ill effects are cumulative and are not eradicated in centuries.

Several of the large towns and cities are supplied with river water taken below sources of deadly contamination and only escape its consequences for a time and probably not to the extent that they imagine. In the event of the occurrence of filth diseases of a virulent type above these towns it is difficult to see how they can escape serious visitations of the disease. At this point it is proper to call attention to the illegality of discharging foul matter into the streams of this State and the lax administration of section 374 of the penal code. It will thus be seen that there are too many instances of either ignorance or carelessness as to the water supply of homes, and it is the duty of every house holder to look carefully to this, the most ready course of filth disease into the system.

THE CONDITION IN THE CITY OF SAN FRANCISCO.

The water supply of San Francisco is obtained from several sources, the major portion coming from sources of undoubted excellence. There are two minor sources whose area by reason of growing population and neglect are rapidly becoming dangerous if not already so.

*Page 3, Textbook of Medicine, Strumpell.—Page 4, Practice of Medicine, Oster.

The catchment area of Mountain Lake and Lobos Creek, embracing some 1500 acres, all within the limits of the City and County, is fast gaining in those conditions which pollute both the surface and underground drainage. The most glaring of these conditions are :

1. The absence of any sewer system with proper outlet.
2. The existence within its area of a hospital connecting with a sewer without any outfall.
3. The existence of not overclean "dairies."
4. The use of part of the area for cemetery purposes.
5. The dumping of garbage and filth as filling for lots below grade.

The watershed tributary to Lake Merced, some 5,000 acres in extent, is objectionable from the same general causes, although less in degree and extent.

The area tributary to the present Alameda Creek source will have to be abandoned in the future for the same cause. All areas from which a municipal water supply is drawn should be kept absolutely free from human habitation, and it would be a wise measure for municipalities in a growing country to acquire catchment areas and afforest them. In this way valuable forest reserves could be made for all time, and the area made as valuable for timber as ordinary farming lands, and by the proper selection of the trees to be cut the area made a source of permanent timber supply.

The house tank, when not kept scrupulously clean, is a source of contamination even when pure water is supplied. When not absolutely necessary they should be dispensed with.

Water is the most active disease distributor imaginable, and to paraphrase the very truthful words of a celebrated authority —"No power upon earth could save San Francisco from the scourge of cholera or typhus were a single case to occur or a single infected garment to be washed in one of the watersheds supplying the city with water." The use of a water supply from areas partly within our city limits should be immediately prohibited.

In this connection it may be well to quote from the recent law of the State of New York,* which, in providing for the purity of the water supply of her chief city, conferred upon the Commissioner of Public Works powers possessed only by the most tyrannical governments. Yet these powers were wisely conferred and are being

*An Act to provide for the sanitary protection of the sources of water supply for the City of New York. Approved March 23, 1893.

justly and wisely executed; for never can the power of law be more humanely and justly exercised than in the enforcement of those conditions which prevent the introduction and spread of filth diseases. In this remarkable law the Commissioner of Public Works was authorized to enter in upon the lands and homes of persons breaking the imperative laws of cleanliness, and even to burn up and eradicate every vestige of possible contamination. $1,500,000 is made available in three equal sums for three years.* Such action is necessary in the face of the fact that during the years 1832, 1848, and 1866, cholera had entered that great mart and paralyzed every industry and brought death and sickness in its most frightful and disgusting forms to her homes.

In 1873, cholera devastated the southern and western portions of the United States, but it gained no foothold in New York by reason of the rigid quarantine measures and excellent control of the imported cases.

DISPOSITION OF GARBAGE AND WASTE.

The degree of carelessness and inattention reached in San Francisco to this important sanitary matter is unequaled in any part of the United States. In this City the matter has long passed the stage of official and criminal neglect, and reached that of civic indifference.

Many lots and streets in the northern part of the City have been filled up with highly putrescent matter which cannot be excavated for foundations, sewers, pipes, or conduits of any kind within the next few centuries without endangering human health and life. In the center of the City, and in a district which is surrounded on all sides with dwellings or stores and factories, is an area of many acres already piled from 10 to 20 feet deep with foul and putrifying garbage. During the prevalence of a west wind this pest breeding spot can be smelled a mile or more from shore. With every south wind its pestilential odors are blown through the heart of the City. Its foul smell can be detected not only along the adjacent low-lying districts, but at elevations 300 or more feet above tide water and a

*The New York Academy of Medicine realizing the vast importance of pure water, drafted and presented a bill providing for—

1 *Croton Water Commission, consisting of five members.*
1. The Commissioner of Public Works—President.
2. The Commissioner of Public Health—a Physician.
3. A member of the State Board of Health—a Physician.
4. A member selected by the Chamber of Commerce.
5. A member selected by the American Society of Civil Engineers.

This Board appoints a civil engineer who has power to carry out permanent plans, systems and methods for securing pure water. $50,000 is appropriated for the year 1893, and $20,000 for each year thereafter.

mile and a half away. After a few hours south wind the course of this foul air can readily be traced by dull headaches, and later by influenza and sorethroats if nothing worse.

From 250 to 300 loads are daily added to this pest heap, which in aggregate is more dangerous than a dozen well-conducted hospitals for pestilential diseases. Indeed when the truth is known, vastly more disease can be traced to these sources than to the hospitals; and in fact they are one of the prime causes making the maintenance of pest houses necessary. We have been recently treated to prolonged and bitter discussions as to where a pesthouse should or should not be located, when in our midst conditions are tolerated which are manyfold worse than a pesthouse full of patients, and which may under favorable circumstances make a pest house out of the homes which we have built for ourselves and families, and which repeatedly fill those homes with air too foul to be pleasant and undoubtedly dangerous; and which greatly adds to the danger from the hundreds of local defects in our sewer system. It is not necessary to here anticipate a report now in process of compilation, but it may be safely said that we are running risks which only our unparalleled natural advantages enable us to do with partial impunity. That we do not entirely escape is known to every citizen, for there is not an intelligent being in this City who cannot recall many preventable deaths. Oft' times, alas, of relatives or friends.

These views are the result of years of observation, and are in harmony with centuries of experience. They may not meet the approbation of those whose interests lie in an easy and profitable disposition of this material, nor of those who desire a cheap filling for valuable tide lots. There are interests at stake in every community which are not in harmony with a proper administration of the law. But it is the imperative duty of every man to see that the true needs of the community are subserved. The hope is therefore expressed that the members and our guests will freely express their observations and views, for "in the multitude of counsellors there is safety."

NOTE.—Owing to the illness of the stenographer, the discussion of this paper could not be printed this month, and will appear in the next number of the Proceedings.

SOME PROBLEMS IN PUMPING FLUIDS.

By J. RICHARDS, Mem. Tech. Soc.

[Read June 2d, 1893.]

The writer, in an experience extending over ten years past, has met with some problems in raising and impelling water, that it is believed can be presented here with advantage. At first it was thought that these problems could be presented with both graphical and mathematical illustrations that would, no doubt, have added a good deal to the value of the paper, but on consultation with the Secretary, Mr. von Geldern, and with Professor D. E. Hughes, it was found that previous to treatment in this manner a certain amount of fact and data of various kinds must be prepared as premises. The reason for this will appear further on.

In raising and impelling water we employ pumps of various kinds in respect to arrangement and construction, but all coming within three classes familiarly known as piston pumps, centrifugal pumps, and the positive rotary kind. There are other modifications that do not seem to come within these classes, such as ejectors and pulsometers, but as ninety-five per cent., if not a larger proportion of all pumps in use, belong to the two classes first named, piston and centrifugal, the present remarks can be confined to these. As between these two types there are at least twenty times as many piston pumps as centrifugal ones, so the former comprises ninety per cent. of all in use.

To present as soon as possible some clue to what we are to consider this evening, if one examines the trade circulars relating to these classes of pumps some queer facts will appear. Confining such examination to what are called commercial pumps, that is excluding special pumps, such as are made for public or municipal water supply and like purposes, it will be found to begin with that the duty of the two kinds of pumps are about as ten to one in favor of the centrifugal type, if we compare them on the basis of their bore, diameter, or flow capacity. For example, a piston pump of 8 inches bore is set down for a duty of 120 gallons per minute, and a centrifugal pump of like bore at 1,200 gallons per minute, the proportion being ten to one. Remember this comparison is made on the basis of the flow capacity, and section of the water ducts through these pumps, and has no reference to their efficiency or con-

sumption of power in proportion to the work performed.

We will next compare them in respect to cost, or investment as water-raising mechanism or implements, including some means of connecting to motive power. This latter would have to include in the case of piston pumps either a steam engine directly connected, or a crank shaft and other gearing, so that the cost of the two pumps when compared on the basis of their bore will not vary much from two to one if we consider the weight of material and the cost of construction. The flow capacity in the two cases, as we have seen, is as ten to one, and this, qualified by the first cost of the two machines, shows that a piston pump costs for a given volume or duty twenty times as much as a centrifugal pump.

In respect to efficiency, or the consumption of power in proportion to the work performed, and still confining the comparison to the commercial classes of pumps, the difference in efficiency is also in favor of the centrifugal type. An evidence of this lies in the fact that the trade circulars issued include the efficiency of centrifugal pumps but not of piston pumps. Contracts made for centrifugal pumps nearly always include stipulation as to the duty to be performed with a given amount of power, but this is not the custom in respect to piston pumps of the commercial class, and their efficiency is, no doubt, much less.

There is plenty of data respecting centrifugal pumping, but not of piston pumps of the class we are now considering, and such as are commonly supplied for purposes such as centrifugal pumps are employed for, in irrigating works for example. The operating conditions, such as endurance, liability to derangement, steadiness of motion, with other circumstances of use, are in favor of the centrifugal pump. It is, of course, understood that in such comparison there must be taken into account limitations of head or pressure, and other things, that prevent the use of centrifugal pumps in many cases, but this is not important for our present purpose, which is not to frame an argument in favor of centrifugal pumping, but something quite different, as will presently appear.

This comparison has been made to show the economical difference between continuous and intermittent action, which is the chief distinction between these two methods of pumping. There is no reason why 1,200 gallons per minute could not pass through the piston pump the same as it does through the centrifugal one, if there were not limitations of some kinds that take away nine tenths of the capacity of the piston pumps.

As at first remarked, this difference between the two methods of pumping seems to rest in "constant flow" in one case, and "intermittent flow" in the other case, which is mentioned at this time in advance of its proper place to enable a better understanding of some further comparisons to be made. By examining lists of centrifugal and piston pumps it will be seen that the suction and discharge pipes of the former are made of a larger diameter than the pump's bore. In this State the smaller class of centrifugal pumps are usually made with discharge pipes having four times the capacity of the pump nozzles, the suction pipes the same. To quote an exam-

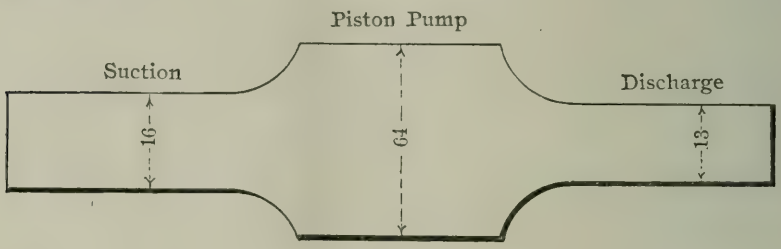

Fig. 1

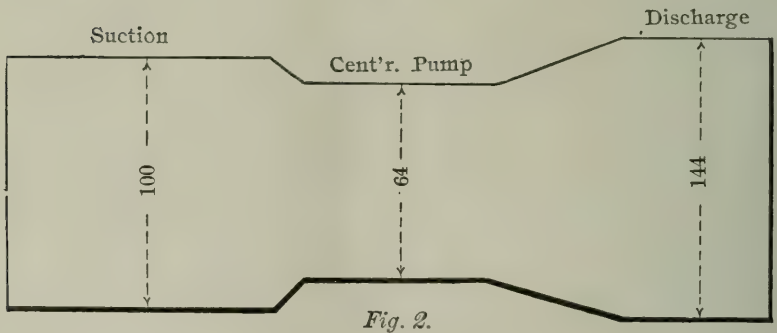

Fig. 2.

ple, or several examples now in mind, the diameter of the pump nozzles are five inches; diameter of the uptake pipes, 10 inches. Suction pipes, of which there are from two to four, 6 inches; suction inlet to pumps, 8 inches. With larger pumps these proportions do not hold, but the pipes are in all cases made larger than the pumps to which they connect.

Turning to piston pumps we find the pipes with capacity only a third or fourth as much as that of the pump's bore, or, comparing with centrifugal pumps, about one seventh as large, and are in proportion to the flow in the two cases. Here then is an anomally, two

machines for impelling water under like conditions for average heads, one costing twice as much as the other and performing one tenth of the duty. Behind this must lie some potent feature of method or operation which we find primarily in the difference of velocity at which the fluid passes through the pumps, and from that can lay down a first postulate as follows:

The dimensions, weight, and first cost of pumping machinery are inversely as the velocity with which the water passes through it.

The velocity which we have seen is as ten to one, or thereabout, can be illustrated in the two cases by diagrams, as in Figures 1 and 2, where the ordinates represent the diameter or capacity of the water ducts in the suction pipes, pumps, and discharge pipes as taken from actual practice here in California.

These comparisons have been dwelt upon for the purpose of showing the low duty performed by the reciprocating piston type of pumps, and to set forth in as plain a light as possible their possibilities under a continuous flow, as illustrated by comparison with other pumps of the constant flow type.

This branch of the subject can now be left to trace out the causes of this difference, and why, as in the case of piston pumps, water is moved by "jerks," so to call it. This limitation is found in the variation and cessation of velocity of the water in the pumps and usually in the suction pipes, and when considered as a dynamical problem the wonder is that a flow of even 1.5 feet per second can be attained in this manner of pumping.

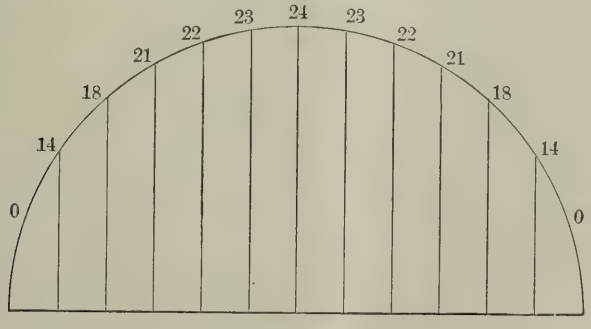

Fig. 3

The ordinates in Fig. 3, and the figures set opposite, represent one stroke of a crank-moved pump piston, showing the changes of velocity, and from this we can derive a second postulate as follows:

The limitation of duty in reciprocating piston pumps amounting to from eight to nine tenths of their normal capacity is due to intermittent and irregular flow.

It must not be imagined, however, that a crank piston pump operates under a regular cycle of pressures, as indicated in the diagram. The actual performance is much worse, and indicator diagrams taken from the pump chambers are so imperfect as to suggest a much greater loss of capacity than really occurs.

Reverting further to this matter of irregular flow or velocity, and the important part it plays in pump performance, a good way to appreciate the fact is to imagine the same method applied to the movement of weights in other cases. Let us suppose, for example, a railway train, a boat, or an elevator, propelled or moved in this manner, and the mean velocity reduced to one tenth by such movement. The proposition is too absurd for consideration, and yet this is precisely what we do in pumping, and in the case of nine tenths of all pumps in use.

It should be mentioned that in the case of direct-acting steam pumps the movement of the steam piston accommodates itself in a degree to the resistance of the water, producing a diagram different from Fig. 3, but the limitation as to velocity is nearly the same in practice as in the case of pumps driven by crank movement.

Now, it may be asked, what practical result can there be in view in thus presenting this matter? Can piston pumps be made to operate by continuous flow, and how is it possible that a class of machinery that has had the attention of the most eminent engineers for centuries past should operate under such unfavorable conditions? This brings us to the second section of this paper.

Notwithstanding this subject is new in so far as common practice, it is not new in respect to all practice, and there are unmistakable signs that very soon there will be a considerable change in the methods of pumping.

In no other portion of this country, and perhaps not among an equal population in any country, is there so much investment and interest in raising and moving water by pumps as on the Pacific Coast. It may also be claimed that, down to the present time, no other part of the world has contributed more to this branch of engineering work. Designs and modifications of pumping machinery made here have attracted attention and approval all over the world, and it will be anomalous if this matter of increased capacity is not taken up, and pressed forward here the same, or to a greater

extent, than in other places. To this time this is not the case, and the present purpose is to call the matter to the notice of our members, among whom are a large number connected with, and favorably known, as designers and makers of pumping machinery.

In no other place is there such an amount of accumulated data respecting pumping against high pressures. Centrifugal pumping machinery has been improved beyond what has been attained elsewhere in respect to efficiency and other working qualities. The adaptation of direct-acting pumping engines to marine purposes, and especially to war vessels, by G. W. Dow, of this City, is a distinctive advance on what has been done in any other place or country. These improvements, which do not much concern the general public, have not been given out in the usual manner. Under these and other circumstances to be hereafter mentioned, it is a wonder that more attention has not been given to what is going on elsewhere, and of which some notice will now be made.

Professor Riedler, of Berlin, Germany, about ten years ago began a series of investigations respecting the action of piston pumps that with some other experiments of the kind is destined, no doubt, to cause a great change in practice, indeed has done so at this time in Europe, and is working its way here in a significant manner.

Professor Riedler's indicator diagrams taken from common pumps are "monstrosities." No one would suspect that such forces as here appear existed in pumps of any kind. Mr. J. C. H. Stut, one of our members, has loaned a copy of Riedler's *Indikator Versuche aus Pumpen*, which can be examined by the members at the close of the paper. These researches occupied a period of many years, and led to the appointment of the author to a high scientific position in Germany, and also to his being associated as consulting engineer in the celebrated works in Paris for distributing power by compressed air.

The result of Professor Riedler's researches and improvements was to increase the flow of water through piston pumps to *five feet per second*, or about three times the former velocity, without the least shock or jar. This is a wonderful result, one that is far beyond question at this time, and attained by changes that are in comparison with the results, simple and inexpensive. They consist in positively operating the valves by mechanism independent of the action of the water, and in so constructing the water ducts that there is but little change of velocity as the water passes through the pumps. This work of Professor Riedler's is one principal fact in the history of

this matter, and marks, as we may well believe, the first stage in a progress toward continuous-flow pumping.

Mr. E. D. Leavitt, of Boston, Mass., a well-known engineer who designed the celebrated pumping machinery at the Lynn Water Works, and that of the Calumet and Hecla Mines on Lake Superior, visited the last Paris Exhibition, where pumps were shown constructed on the Riedler system, with the pistons moving at 300 to 400 feet per minute.

The result of this is that the plans for a new pumping plant, designed by Mr. Leavitt for the Boston Water Works, and now being constructed in New York, are on the Riedler system. The pumps are of 20,000,000 gallons daily capacity, operating against a head of 128 feet, or a pressure of 55 pounds per inch, the pistons moving at 200 feet minute, or at twice the usual speed. The water valves are operated positively, and have an area in excess of the pump pistons.

This is, so far as known, the first complete application of the improvements of Professor Riedler in this country, and the result will, no doubt, be the highest efficiency that has been attained, and the capacity of the engine will be double what it would if the pump valves were made to depend on a "reversal" of flow to close them.

Here we have a suggestive example. In a plant costing $150,000 there is a saving of from $40,000 to $50,000 in first cost, and a double capacity for a given weight of machinery, attained mainly by an approach to continuous flow, that is, by not reversing the water to close the valves, with some other refinements.

Mr. Hall, of Plainfield, New Jersey, the inventor of the Hall Duplex Pump, one of the most ingenious and efficient of its kind, is now engaged in experiments that point toward continuous flow in piston pumps. The only information respecting his investigations and experiments known to the writer is found in some recent patents granted to him for such improvements. From these it may be inferred that he has discovered the limitation of reciprocating pumps, and is trying to remove them as Professor Riedler did, but in a different manner, by an uniform working stroke of the pistons, a quick return stroke, and free water ways so the water will move continuously.

Fig. 4 shows a side view of one of Hall's continuous-flow pumps. His method consists in employing two bucket pistons in what is called a **U** barrel, which is simply one barrel in the form of that letter, so the pistons while moving, coincidently in fact, are

moving reversely in respect to the water. There are no valves except in the pistons, which are driven by means of cranks and links so as to produce a nearly uniform forward stroke and a quick return, the pistons acting alternately, so there is no difficulty in maintaining a constant flow at a low velocity, perhaps not exceeding five feet per second. Mr. Hall in his specification says:

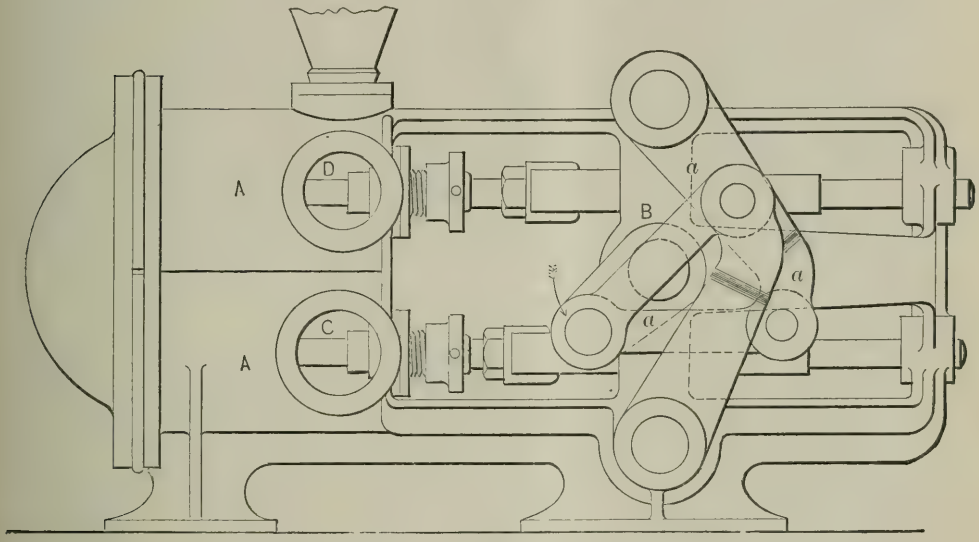

FIG. 4.—HALL'S CONTINUOUS FLOW PUMP.

"Pumps, as ordinarily constructed, impart an intermittent movement to the column of water, the column being first lifted by the thrust of the piston, and coming to rest and remaining seated against the check valve during the return stroke of the piston, so that upon the beginning of the next stroke the column has to be again started against the resistance offered by its inertia."

The writer has had the advantage of conversing many times with Mr. Geo. W. Dickie, an officer of this Society, and also with Mr. W. R. Eckart, also a member, respecting the phenomena that attend on deep pumping in the Comstock Mines with intermittent flow pumps. This experience might be called a "mechanical romance," and if Mr. Dickie could be induced to present some account of it here, it would go to confirm some of the propositions laid down in this paper.

He might also include if he chooses some mention of a pump constructed for him by the author in 1886 that was a puzzle to all

concerned. It was a double-barrel bucket pump with two pistons moving together, and without valves except in the pistons. It was operated by a crank, and a steam engine forming an integral part of the structure, and in performance was, perhaps, the most noisy pump ever produced, and a failure, because of concussive shocks which no one could find any reason for. It will not be creditable to admit that the cause of the pump's peculiar action was discovered five years later by some experiments with a single-acting hand pump.

The explanation is this, the speed of the pump, its methods of construction, and the length of its pipes, made it a continuous flow one, and when the bucket pistons started out on the accelerated portion of their stroke the water was moving at a higher velocity and outran the pistons, but when they overtook the water, the result was much like the action of a steam forging hammer. We had produced a continuous-flow pump and were not aware of it.

Mr. Robert Hall, a maker of pumps in this City, and a member of this Society, makes various pumps that operate by continuous flow, and has not among his patterns and designs any that call for intermittent or arrested flow at the extremes of the stroke. He makes no double-acting pumps that stop and change the flow at each stroke, and very clearly recognizes and understands the principles involved in continuous flow, and applies them accordingly, so far as is possible in his business.

Any single-acting hand pump with a suction pipe of some length becomes a constant flow one, and its valves never close except when the pump stops. The hand movement follows the water or impells it in accordance with the velocity of flow, and the amount of water delivered by such pumps is frequently fifty per cent. or more greater than the theoretical displacement of the piston's range.

Since the foregoing was written the following notes have been appended:

Two well-known engineers in England, Mr. Arthur Rigg, of London, and Mr. D. H. Morton, of Glasgow, have been engaged in a discussion in the *Engineer*, London, over the subject of pump capacity.

Mr. Rigg goes so far as to claim that by attending to all possible improvements the speed of pump pistons, and the water moved by them, can be raised to the same speed attained by centrifugal

pumps. In support of this proposition he presents drawings of a piston pump that has been in use several years, in which the flow or piston speed is about 8 feet per second.

Mr. Morton disputes the possibility of attaining so much, but admits that a great increase of duty is possible. He is a conservative engineer of wide experience in pumping machinery. The following is a quotation from his writings on the subject:

"The high-speed direct-acting pumping engines constructed by M. Farcot for the Paris Waterworks, St. Maur, and elsewhere, in 1871, 1876, and later, seem to fulfill all the requirements which continue to secure successful running at a bucket or piston speed of 350 feet per minute. These pumps have large water chambers, very well formed passages, judiciously placed air cushions, and multiple, or rather sub-subdivided, valves, in design probably very much better for flow than a group of discs. The pumps erected by Messrs. Simpson at the West Middlesex Water Works, Hammersmith, ran on their trials at 290 feet per minute; it is fair, however, to state that in this case the stroke is 8 feet, though speeds of 240 feet per minute are not uncommon with 4 foot stroke in the practice of Messrs. Simpson and others. Engineers who are familiar with the best forms of the horizontal direct-acting air pump are aware that but little modification would be required to convert it into a successful water pump with a piston speed of 300 feet to 400 feet per minute, due care being taken that the water chamber and valve area bear a proper relation to the displacement of the bucket and the speed proposed.

From time to time very pretty and ingenious designs of high-speed pumps have been produced by French, Swiss and Austro-Hungarian engineers. In principle these have generally been of the bucket and plunger, or of the piston and plunger, type, frequently so cleverly disguised as to be beyond casual recognition. Pumps of "unlimited delivery" and of "continuous flow" seem indeed to be very much in the minds of our continental friends, and the sections of many of these pumps, presumably the work of small firms, show an intelligent appreciation of requirements, which is highly creditable to their designers. Some time ago I had an opportunity of seeing tried a small French reciprocating pump whose crank shaft made 250 to 300 revolutions per minute, and although it was not deemed advisable to proceed to make such pumps in this country, the example is interesting as showing what is possible. This type of pump was to be seen at work during the last great exhibition at Paris, the moving parts are simply a bucket and plunger, the foot valve is dispensed with, as once started, the suction column of water has no time to come to rest or fall back."

In a recent notice of a duplex pump, designed by Mr. Thomas Holehouse, at Manchester, England, there appears the following words:

"The pistons are driven at from 300 to 500 feet per minute, at which speed the pumps deliver a continuous stream of water, no pulsation being noticeable, and there is an absence of noise and shock. The valves, waterways and pipes are of large area so as to give as free passage as possible to the water when working at high speed."—*Industries*, April 7th, 1893, No. 354.

In conclusion I am conscious of having occupied your time with a paper of suggestion rather than one of theory or facts, perhaps for reasons that will be sufficiently plain, and, while I am not authorized to say so, it is probable that Prof. D. E. Hughes, a member of this Society, will, at some future time, present here, in a mathematical form, an analysis of these limitations of reciprocating pumps for moving fluids.

DISCUSSION.

MR. RICHARDS.—"I have recently been called upon to make plans for some centrifugal pumps of 24-inch bore, twenty pumps in one battery. The cost of this plant is $95,000, including water wheels to propel the pumps. Piston pumps to do the work would have cost more money than the Irrigation District has provided for all purposes. In other words, piston pumping was absolutely out of the question, and could not be considered.

THE PRESIDENT.—"We would be pleased to hear from Mr. Stut in explanation of the diagrams referred to by Mr. Richards in his paper as being in Mr. Stut's possession."

MR. STUT.—"I have here the diagrams referred to by Mr. Richards. I would state first, before showing the diagrams, that Professor Riedler started in 1875 upon this work, and then he worked from that time on, I think six years. After he had made all the diagrams, he could not find a publisher, as it was thought they would not be of sufficient interest and that it would not pay. Finally he had to do it himself, that was in 1881. As soon as these diagrams came out I had copies of them, and have had ever since. I exhibited them to several gentlemen in town here, but even with the diagrams they would not take any interest in them, they thought it *might* be a good thing. Now I find that Professor Riedler has been constructing several stations according to his plans, sixteen I believe, and there will be more. So I thought I would make a few remarks in relation to this, so that the members can see how far we are behind on the pumping question."

(At this point the members examined the diagrams, and talked among themselves.)

In answer to a question Mr. Stut said: "They are all deep-mine pumps."

THE PRESIDENT.—"Mr. Dickie, we will be pleased to hear from you."

MR. DICKIE.—"Mr. President, I had no intention whatever of taking any part in this discussion tonight, I cannot very well trust myself to go into this subject. My friend Richards and I dined together tonight, and in order to explain intelligently any mechanical subject, that kind of a pump that the medical fraternity applies would have to be put in operation.

Mr. Richards has described, and I think very clearly described, the two types of pumps that do the great majority of the pumping that is done; the centrifugal pump that impels a body of water as one throws a ball in the air, which will go as far as the momentum will carry it, and the reciprocating pump that overcomes the inertia of the water, starting and stopping a volume of water at each stroke equal to the cylinder in which the piston moves. The centrifugal type of pumps will be limited to heights of a hundred feet and under, I think, and I doubt the wisdom of trying to make continuous-flow piston pumps with low heads, because it cannot be done with the same economy of production in the machine as the centrifugal pump can. Neither do I think that the centrifugal pump will ever be used to any great extent for heads of over a hundred feet, beyond that we must depend upon the reciprocating pump.

A good deal has been said tonight about what Professor Riedler has done in connection with pumps. He was in the City this week, he did not call on me, and I am sorry, because I think I was entitled to a call from him, he and I have been contending for some years, and I would like to have seen him.

In 1875 the question of deep pumping on the Comstock began to assume a very serious aspect, and while there was not much opportunity to publish the data that had been collected, a great deal of very valuable data at that time, a large amount of it is still in existence; I think that Mr. Eckart, perhaps, has more of it in a form that makes it of some value than anyone else. At that time he and I were opposed to each other in the matter of pumping, that is, we had separate interests, and a great deal of rivalry in design was manifested. I took a certain position on this question, and in order to make it clear to those who were investigating at that

time this kind of work, we published a book on pumping and hoisting, and other mining work, but principally on pumping. In that work the position that I took was that in deep-mine pumping, the engineers who first undertook to accomplish anything started out with the proposition that the operation of a pump had to be represented — begun, carried out, and finished — during one stroke of the pump. That principle has obtained in pumps working under high heads up to the present time, that had to give a high duty. Those were the best types wherein the whole operation was begun and ended in one stroke. There the mass of the moving parts of the engine, and the mass of the moving pitwork was taken into account, and the point of cut-off of the steam would depend entirely on the velocity given that mass, and the whole machine would come to rest when the momentum had been expended. Just as you would throw a ball into the air, and it would continue moving as long as the momentum would carry it, that was the principle of operation of the Cornish pump. There was no limit to the length of the stroke, because it always came back to the starting point, and the Cornish engineer found out one thing that he never forgot, and most engineers dealing with pumps have not forgotten it, that a sufficient amount of time must be given the valves, in order that they may properly seat themselves before the next stroke begins, and even in moderately high-speed direct-acting pumps, the effort is still made to get a pause at the end of the stroke. If you will notice the Worthington pump, his idea in the conception of that pump was to have each of his pistons rest at the end of the stroke, so the whole work would begin again, and the complete operation of pumping was begun and ended during one stroke. I think the tenacity with which engineers have adhered to that principle, has done a great deal to retard pumping with reciprocating pistons.

When the proposition was made in the Comstock mines to go to great depths by hydraulic pumping, one of the principal arguments I made at that time was to avoid the excessive weight of moving parts, and thereby be able to obtain a high piston velocity. We had sets of pitwork over 3,000 feet in length. On the Belcher Mine there was one that was 3,700 feet in length at that time. Such masses could not be stopped and started without a certain loss of time. I made the proposition then that a hydraulic pump, including the surface pumps, which were to be direct acting, could be made to make ten strokes of twelve feet, making 240 feet per

minute, and that the hydraulic pumps at the bottom could make the same speed, and this speed was obtained.

On the surface of the Chollar and Norcross and Savage shaft the surface pump was a compound differential one with a stroke of 12 feet, cylinders 40 and 78 inches diameter; it worked against a head of 1,100 pounds pressure, probably the largest pump of the class that had ever been attempted, and yet there was no difficulty in making that pump work 11 double strokes. That is very nearly as high a piston speed as Prof. Riedler claims now. The pump valves were very heavy and seated by springs, the area of the valve was twice the area of the pump ram. To avoid the inertia of the water, a very large vacuum chamber was fitted, and it was exhausted mechanically, and placed very close to the suction valves of the pump. Then there was a large accumulator that received the water from this pump. Probably that was the first instance of an accumulator made without a moving piston, and this accumulator was charged with air, of course, the air had to have the same pressure as the water, 1,100 pounds. The accumulator is 42 inches in diameter inside and 96 feet in length, made of cast iron, 5 inches in thickness; the depth of water in the accumulator about 10 feet, and above that was the air pressure. The fluctuation of the water in the glass on accumulator was very slight.

In this same work on pumping I went extensively into the question of compressing air, describing and telling why it was necessary in compressing air to have some time to take off the heat, and advocated compressing in two stages. That is the system being introduced for power distribution today by Prof. Riedler, and when the question came up, and they introduced that system in Chicago, it was very gratifying for me to know that Mr. Eckart refused to take a hand, because this machine was identically the one that I had built in 1876. My machine is stored in some warehouse in San Francisco, I do not know where, but it has a story.

There were a great many interests at that time in the mines. Different classes of people wanted matters attended to in different ways. One class of gentlemen wanted things to fail, because they were short of stock and desired to buy some. Others wanted it to succeed, because they had too much. It depended on your friends whether your plan would succeed or not. There was at that time, 1876, a compound air compressor built. The steam cylinders were 16 and 32 inches, and 4 feet stroke, intended to compress to six atmospheres. The machine was all finished and

foundation plates put in. It was intended for the Crown Point and Belcher Mine, and there had been a change of directors in that mine just when the machine was finished. It was tested in the shop; we got it running and took diagrams of it at both ends. I believe they are in existence today, and they are precisely the same diagrams that the Professor gives for his machines. For reasons best known to those then in power, this machine was never set up, it lies somewhere about the City today, and the Professor should have gone to see it.

One of the great difficulties that we encountered in the pumps on the Comstock was in connection with the first one that was put in. Water was discharged at the Sutro Tunnel, that is, the 1,600-foot level, and the first set of pumps was put in at 2,400 feet, that raised the water 800 feet in one lift. Those pumps made a speed of 240 feet. They would average for sixty days at a time 240 feet speed of piston. They were working with pressure at the surface of 1,100 pounds, plus 2,400 feet down to the station. They worked in that way for one year, and then an agreement was made with the water works, and water was delivered at a 400 feet head at the neck of the shaft. Diagrams were taken of the pumps at one time about every fifteen minutes, and they were excellent; there was no fluctuation of pressure. The exhaust pipe to the pumps, taking the water back to the surface, kept continually bursting at from six to seven or nine hundred feet from the surface. They were quite as heavy there as down at the 2,400-foot level, but there was no possibility of keeping them in shape; they would burst. We had indicators for pressure put there, and for awhile we despaired of being able to get at the pressure that would show at that point. Then I put in a small air chamber, about three feet in length, of small pipe, attached to the pipe of the pressure gauge. When the pumps were at rest, the pressure would be 400 to 500 pounds, just as it ought to have been at that point. When the pumps were set in motion, it would go down to 200 pounds, and sometimes down to nothing, and from that to 3,000 pounds at that point. We finally found by experience that a certain velocity gave a certain result. There was little time to reason all this out, because people were very anxious. Well, we put in an air chamber at the 800-foot level, charged it from the air compression machine at the surface. These chambers were made about 24 feet in length, and 12 inches in diameter. As soon as the chamber was put in at the 800-foot level we had no further trouble whatever.

At the 1,600-foot level precisely the same experience was had, and we resorted to the same thing. When those two points were taken care of, there was no further trouble thereafter; we did the same with the discharge of the pump. Four hundred feet below the discharge of the pump we had to put in a large air chamber, besides the one down at the pump, in order to take up the shocks. The least change in the velocity of the pump and the action of the valves would cause a sort of hammer in the pipe. It appeared as if one body of water would leave the other; the pressure would go back, and then the settling back would cause a concussion that would reach 3,000 pounds to the inch. We had a three months' siege of that, but we finally reached a point where we had no trouble at all at that high speed."

The valves were regular disc valves; simply a hard rubber disc set in the recess of a valve that was three inches in thickness; some of them were cast iron; they were all of the same type and set in a cage; no spindles, nothing to work on, simply set in a cage. I do not think that with long stroke pumps anything better could have been done under the circumstances, than was accomplished with those pumps. The limit of deep-mine pumping has been fixed, there is no variation to it. It is fixed by the weight of pit work, and all that constitutes the moving mass. There is no possibility of departing from a fixed rate of speed.

A great many curious phenomena were developed later, as to how the stroke of the surface pumps compared with that of the pumps at the bottom. Mr. Eckart made some very clever and extensive researches in this direction. But there have never been such difficulties as Prof. Riedler points out here, in San Francisco, with deep mine pumps. Those difficulties were, no doubt, due to small valves and small pipes. The fact is, that in pumping for the mines, it has been held that the pipe should never be less than the diameter of the plunger of the pump, and this should be equaled by the area of the valves, and on that account the efficiency of these pumps has been very high. The capacity has been low on account of the difficulties pointed out by Mr. Richards, the difficulty of overcoming the inertia of great masses of water. The flow of water should, I think, be made continuous if possible, and then I think the pump can be run to a very high speed, and my impression is that all high-speed reciprocating pumps will be made with mechanism to work the pump valves, which, like the cylinder valves, will have a fixed motion, and that the openings will at all times be in proportion to the velocity at the given point."

PROFESSOR KEITH.—"This, to me, is an exceedingly interesting subject, for the reason that electric motors, which I manufacture, are connected with a great many pumps in this City and elsewhere. We have found in practice that the best results are obtained from the piston pumps invented by the author of this evening's paper. The piston speed in these cases has been limited to approximately 60 feet per minute. We find that if we increase the speed to any great extent, there will be considerable liability of breakage of the crank shaft. Of course the duty of such pumps is a very low one, but their efficiency at least is as high as any reciprocating pump we know of. The pressure is more nearly constant, and that seems to be necessary in the working of electric motors. It has seemed very desirable in pumping, to produce a continuous flow, but the experiments so far with centrifugal pumps, or constant flow pumps, have not been very favorable. We have not gone very deeply into it however.

Experiments with centrifugal pumps have been tried until quite recently on such as could be obtained in the market, and for elevations exceeding 100 feet we have had scarcely any experience at all. With less elevations we find this condition to prevail, that the pumps which have been tested and attached to electric motors, have been too large, even the smallest pump we could obtain has been too large in its capacity. You must know that in driving centrifugal pumps, the amount of power, apparently a very large percentage, perhaps 75, or 80, or 90 per cent., seems to be used in gaining the velocity of the water, or the pressure which would insure a velocity in the pipe; and if the runners be large, we have a pressure to overcome that is due to the area of the runners, before we can even lift a drop of water to the desired height. Take a pump that will throw a hundred gallons per minute to any given height, and a large percentage of the power is necessary to lift out even a drop of water. A small addition will carry a large amount of water out of the pipe, and for the reason that insufficient attention has been given to centrifugal pumps, we have no data upon which we can estimate as to whether such a pump will be efficient or not. I have heard it stated, as by Mr. Dickie, that probably a centrifugal pump would not be efficient above 40 feet, and some say 50 feet, and some say a 100 feet. I do not know upon what data they base such an opinion. It may be that centrifugal pumps can be so constructed that they will be highly efficient at a 100 feet or more, but I do not know that such a thing has been done. It is very desirable, indeed, to attain

a high efficiency, as well as a high speed in the moving of a column of water. Such a speed has not been obtained by pumps such as we have found best adapted to the running conditions of electric motors, where it is desirable to have the pressure as nearly constant as possible."

PROFESSOR GALE.—"I have been greatly interested in Mr. Richard's paper, which is very timely, and the subject is worthy of a great deal of attention in San Francisco and in this vicinity. We have built some of the best pumping machinery here, and I have also seen some of the worst pumps here that I ever saw. I think that a great deal can be gained by ventilating the subject. There are several statements in the paper which are new and very interesting to me, and I would like to get a little more information in regard to one or two things which are mentioned incidently.

One statement was made of a pump discharging 50 per cent. more than the capacity of the cylinder. That would be a very interesting thing to get a little further data upon if possible.

Then the statement was made that the efficiency of the centrifugal pump is greater, probably, than the ordinary commercial reciprocating pump. I think that statement would be a surprising one to most engineers, at least it was to me. And the reason given for it in the paper seems hardly sufficient, that is, that the efficiencies are published in the catalogue in regard to the centrifugal pumps, while the others are not. I think the efficiencies of the ordinary commercial pumps are easily obtainable in many cases, and that there are many cases on record of the efficiency of such pumps, and if the two pumps were compared it would be very interesting. I had always supposed that centrifugal pumps were lowest in efficiency, except for very low heads; I have not looked into the subject for two years. Two years ago I looked it up to some extent, and came to the conclusion that, except in extreme cases, the centrifugal pumps were lower in efficiency. Therefore I would very much like to get at the efficiency of recent centrifugal pumps, for if their efficiency be higher than that of the reciprocating type they should be more generally used, because the centrifugal pump is cheaper, and its delivery very much greater.

The main part of the paper I do not feel competent to discuss, but I am much interested in it, and think the information and the suggestions which it contains, are very valuable. I hope Mr. Richards will add a little in these directions before it is published."

MR. A. T. HERRMANN.—"We have three deep-well plants in

Santa Clara County that work centrifugal pumps at 100 to 104 feet. One plant lifts 104 feet; it has a No. 5 centrifugal pump, and I have seen it work and give very satisfactory service for several years; it irrigates several farms, and there is an immense amount of water—1,200 to 1,500 gallons per minute. If I had known of the subject of this discussion tonight, I would have taken pains to inform myself better respecting these pumps.

Recently a friend of mine, Mr. S. F. Lieb, one of the most extensive prune orchard owners in Santa Clara County, tried to put up a plant to throw an immense body of water 180 feet. I think it was the San Francisco Tool Company that proposed to set up the plant with a series of three pumps alongside of each other, very near the bottom, and have the three pumps throw one stream. Mr. Lieb is quite a mechanical genius himself, and he made a change in the plans, I wish I could report the success of the new plan, but when they were started there was not water enough. Suffice it to say, that he has three centrifugal pumps attached to the same shaft, one sixty feet above the other, and as long as the water lasted the machinery worked well, but as it only lasted for half an hour or so, the experiment could not be further proved.

Professor Keith said, I believe, that the centrifugal pump cannot be used to over 40 or 50 feet, but I think from these illustrations that that is not so. We have a great many centrifugal pumps in Santa Clara County that go as high as 60 or 70 feet, and people seem to be very much pleased with them, and they would not be satisfied to irrigate their orchards with them, unless it would pay. There is a pump, working under 70 feet head, which has been running for six years, and is doing good and satisfactory work yet."

PROFESSOR GALE.—"I meant to call attention to a pump that has always been very interesting to me, and that is a Corliss pumping engine built for the town of Kentucky. The engine has always interested me because it has a record I believe unsurpassed in efficiency of any pumping engine that is in its duty reckoned for a hundred pounds of coal, and it is also interesting to me because it has a higher piston speed than any pumping engine that I have ever seen of the kind, and higher than any that had been built at the time it was built, I think. The plunger of the pump is comparatively small in proportion to the pump cylinder, and the valve area and passages for the water are very large, so that the water itself moves no more rapidly than in an ordinary reciprocating pump. Just what the details are I do not know, I cannot get the figures at

present that give the efficiency of the steam part of the pump at a high piston speed, and the operation of the pump has always been very satisfactory; I believe its record has never been surpassed by any pumping engine."

MR. DICKIE.—"Speaking again of velocity in pumps, the Spring Valley pumps at Belmont have run repeatedly for long periods of time, making 42 revolutions, that is over 300 feet per minute. These pumps were specially built for high speed, and have been very successful. The pump valves are absolutely silent, you cannot detect the least sound from them, and the air chambers are very large, and are fitted so as to show little or no pulsation in the water, so that the stream from them is an absolutely constant one. We have tried the velocity of the water in the pipes, and we cannot detect the least variation in the flow of the water, and those pumps discharge through about 1,100 feet of pipe to the top of the hill; the pipe is made of sheet iron, and there is no trouble whatever with it. These pumps, and I think the one that was built by the Risdon foundry at Lake Merced, have also attained the speed without any difficulty or shake; all work without any undue wear and tear on any of the pump work.

Speaking of efficiency of centrifugal pumps, Mr. Richards referred to a pump and engine, operating it as a whole, comparing a centrifugal pump with a direct-acting steam pump. In that case I do not think there is any doubt at all of the superior efficiency of the former. The centrifugal pump, well designed and with the runner well cleaned, and a smooth surface, will give 62 per cent. efficiency. We tested one not very long ago, 5,000 gallons for 20 feet, and the efficiency was 64 per cent. With a pump having such an efficiency the engines which operate it are certainly a great deal more than 40 per cent. in efficiency ahead of the cylinder that operates a reciprocating pump. Where heads are low, and the quantity or volume of water is large, centrifugal pumps are ahead. Taking pumps delivering 5,000 gallons a minute at the ordinary speed of reciprocating pumps, that would require a cylinder 36 inches in diameter, and the packing in the water piston would absorb more than the total power required for a centrifugal pump. For large quantities of water under low head the centrifugal pump is unquestionably the best."

PROFESSOR GALE.—"Can you tell us how that figure of efficiency is obtained?"

MR. DICKIE.—"I simply take the quantity of water delivered, the height of the head, and the power developed in the cylinders. I do not think that any direct-acting pump cylinder will work with less than 40 to 45 pounds per indicated horse power per hour. I have noted them as high as 130."

Q.—"Does it average 130?"

MR. DICKIE.—"Certainly an engine used in connection with a centrifugal pump will not exceed 130. The one I am speaking of now was operated by compound engines. But the ordinary engine that is sold with the centrifugal pump is of such a character that its efficiency will be very much in excess of the efficiency of the steam cylinder attached to the direct-acting pump, and so much so that even if the other had a 100 per cent. efficiency the centrifugal pump would be much higher. The runners of a centrifugal pump must be smooth and clean, in fact they have to be faced inside and out. Upon one point I do not quite agree with my friend Richards, he runs the center around and lets the side stand still."

MR. HALL.—"It might be interesting to some of the members to know how much friction there is on the pistons. In making some recent tests, we found that pistons with six inches of bearing on the cylinder was packed to show a 150 pound pressure, and did not leak. It was approximately 25 pounds to the inch in diameter. It seemed to be slightly more at first. There was a little more friction until it got started, and then, after making two or three strokes it improved, but after the packing got swelled the friction increased."

PROFESSOR KEITH.—"I will state, Mr. President, for *practical* approximation, that the amount of power requisite for operating triple plunger pumps for elevator service in this City, for elevations of from 100 to 130 feet, is 50 per cent. above the dynamic value of the column raised at the speed necessary. We have in all cases found that 50 per eent. was ample where the piping was properly done, where there were not too many elbows, and the pipe was not too small, so as to produce a large amount of friction. There was an abundant excess of power above the theoretical one. That would show then an efficiency approximating 66 per cent. in the electric plunger-pump plant. The pistons had approximately a speed of 60 feet per minute, and fairly high efficiency as things go."

MR. DICKIE.—"Professor Keith forgot just now to state the efficiency of his motor. We are getting efficiency from the steam cylinder, the motor gets its power from the steam cylinder. Now we

want to get the power of the steam cylinder that works his motor."

PROFESSOR KEITH.—"I made the statement as to the amount of power proceeding from the pulley of the motor, and included the friction by reason of the belt of the counter shaft, and the appliances which are necessary to reduce the high speed of the motor to the low speed of the pump. The question of the efficiency of electrical transmission is one which was slightly discussed at the last meeting, and is a subject which would take me a considerable length of time to explain here. But the fact remains like this: Without question electric apparatus is made and operated today of higher efficiency than is the case with any other mechanical operation or apparatus. The electric motor, or electric generator, which does not convert from 90 to 96 per cent. of the mechanical energy into electrical energy, or the reverse, is a poor piece of apparatus. Then, upon the assumption of 90 per cent. efficiency of the generator, and 90 per cent. of motor, we have a translation efficiency of 81 per cent. This is very frequently exceeded. From this efficiency are to be deducted losses due to the electric resistances of the conductors connecting the generator and the motor, and these losses may be made as low as desired, even to the smallest fraction of a percentage. I am making this as a broad statement which can be sustained; which can be demonstrated by various examples of electrical apparatus used for the transmission of power."

MR. HALL.—"Without desiring to say anything to the disparagement of the electric motor, or Mr. Keith's statement about percentages. Plants are known to me where the actual foot pounds required figure up 23,000, and they cannot operate with a two-horse motor. I presume that the current is not sufficient; possibly the current does not get to the motor; but that is the fact, that a two-horse motor will not perform the work."

PROFESSOR KEITH.—"I will say furthermore that the smaller motors used, those of a fraction of a horse power up to five or six horse power, are decidedly less efficient than those of larger capacity. The fact is, the larger the apparatus the higher the efficiency, but not in proportion to the increase in size. In all small motors, of one, or two, or a few horse power, the conditions of commercial manufacture almost preclude a high efficiency above, say, 75 per cent. or thereabouts. Then the very small ones may not exceed 60 per cent. of conversion of electrical energy into mechanical power. The reasons therefor are very well understood in electrical engineering."

It may be all true that the work Mr. Hall refers to can not be performed with a two-horse motor. The friction of the belt and the friction of the pump must be taken into account, and, as we know, all small pumps have a greater ratio of friction owing to the larger proportion of frictional surfaces, and therefore the broad statement which I made still holds true, because it refers to larger plants, that is to say 8, 12 and 20-horse powers, such as are used in this City. In mine pumping the amount of power used is still larger, and the efficiencies are still greater than in the case of the small ones. I am not prepared to controvert Mr. Hall's statement, it may be true, and the conditions which accompany it may account for all the results."

MR. HALL.—"In another instance that occurred today with a motor rated at 10-horse power, we were pumping 81 gallons per minute against a 110-pound pressure, and it blew out a 35-ampere fuse with a 235 volt current."

PROFESSOR KEITH.—"Mr. Hall is aware that I know what plant he is referring to, it is not one of mine, and it would be rather invidious to criticize it. He knows how we, together, have criticized the whole apparatus, and I do not think this is the proper time to say anything about it. I am not saying that the machine is not highly efficient, or that the apparatus is incorrect, though I believe it is. We know very well that if we attach a steam engine with a certain piston area, and a low pressure of steam, that it will not start a pump with a column of water, it might be a one-horse power or a 1,000-horse power engine and not perform any duty whatever. It might be attached so as to work to the greatest disadvantage, the same as a steam engine might be attached to the pump and not move it at all, even though the engine were sufficiently powerful to do the work if it had been properly connected to the pump."

MR. HENNY.—"I would like to ask Mr. Richards a few questions about the efficiency, or rather the duty, of the pump for 100 pounds of coal, or 10 pounds of steam. He has referred to efficiency a few times in his paper, and I think sometimes the meaning of the word there was the lifting capacity of a certain size or certain weight. If we could get some exact figures I should like it. For instance, of the pumps Mr. Richards devised for the Sunset Irrigation District."

MR. DICKIE.—"The duty of the Belmont pumps is 98 million foot pounds, presuming that a pound of coal evaporates ten pounds of water. That was the duty at Belmont at the 30-day test, and the

Lake Merced engines have done better. I think some very large plants with centrifugal pumps have shown a duty of 60 millions. Good builders undertook that, and have no difficulty in getting such a result from very large plants. So that a reciprocating pump of the highest type may be said to be 40 per cent. ahead of the centrifugal pump, but not under the same circumstances. We have no instance, at least I do not think there is any, that you can compare with the large reclamation centrifugal pumps dealing with immense quantities of water at a low head. The great lift pumps that were built and operated on the Harlem lakes showed a very high rate of duty, and operated a great many years, but the engines were superseded by centrifugal pumps, notwithstanding that high duty, and I doubt whether any pumps have been built with such great care, following out the old principle of stored up energy at the beginning of the stroke to work out the expansion at the other end.

I think that one part of the discussion has been pleasing, I like to see these electrical gentlemen shown up a little. They have a very peculiar way of estimating power. They talk about mechanical energy, and they never get it, and they have all the excuses in the world — that it goes in the shaft, and in the bearings, and in the insulation — that the insulation is imperfect, and the conductors are too small, and all that sort of excuse. We never have any such. One is measured and the other is measured, and we abide by the result. Electrical gentlemen tell me that their pounds are scientific pounds. I think they must be working on a Troy pound of 12 ounces, and make 33,000 pounds Troy to the horse power."

PROFESSOR KEITH.—"Mr. Dickie is desirous of being humorous for a few moments, but he should know that there are electrical engineers and electrical engineers. Every man who has a pair of spurs and climbs a pole and pulls wire is an electrician here. So there are mechanical engineers and mechanical engineers, and there are those who, so to speak, work upon Troy pounds, and those who work on Avoirdupois pounds. There are men who can tell you the value of 33,000 foot pounds per minute, and there are some who work in the same line, both electrical and mechanical, who cannot tell, or describe exactly, what a horse power is. We can say this much for the advancement of mechanical and electrical science, that the requirements of the electrical engineer have put the mechanical engineer upon his mettle, and the mechanical engineer has, within the last ten years,

improved the steam engine very much to suit the requirements of the electrical engineer.

The electrical engineer measures his power from fundamental units, but he does not arrive at any different horse power than does the mechanical engineer, but he goes at it in a better way than our old friend James Watt did, who, after a long list of experiments with horses, determined that a horse could do a continual duty, or a duty per diem, for the year in and year out, of 22,000 pounds per foot per minute, and then concluded to raise it 50 per cent. to make the thing sure. This was about the time when he congratulated himself that the mechanical engineer had arrived at such a degree of proficiency that he could bore out the cylinder of an engine so that it was hardly $\frac{3}{8}$ of an inch out of round; when the piston was packed with hemp and tallow in order to get a tight fit of piston to cylinder. These things have improved, and the modern electrical engineer has improved likewise.

SPECIAL MEETING, MAY 19th, 1893.

PROCEEDINGS.

MINUTES.

The joint meeting of the Technical Society and the San Francisco County Medical Society was held in the main hall of the Academy of Sciences, on the evening of May 19th. The meeting was called to order by President Grunsky, who stated that the subject of the evening would be open for discussion from a medical as well as from a technical standpoint, and that anyone present might participate.

Mr. Marsden Manson read a paper entitled: "Are California Homes as Healthful as they should be?"

Dr. J. H. Stallard, of the San Francisco Polyclinic, followed the speaker, extending his remarks to the condition of the San Francisco sewer system in particular, and dwelling upon the necessity of improvements; claiming that two thousand deaths annually are due to the defective sewers, and to other causes that proper sanitation may remove.

The discussion of this important subject was continued by a number of others, touching upon the numerous points involved in the question of municipal sanitation.

REGULAR MEETING, JUNE 2d, 1893.

PROCEEDINGS.

MINUTES.

The meeting was called to order by President Grunsky.

The minutes of the last regular meeting were read and approved.

Mr. Geo. F. Low, Electrical Engineer, was elected to membership, and the following propositions were read and referred to the Executive Committee:

For member —

Frank P. Medina, Electrician, of San Francisco; proposed by N. S. Keith, H. T. Bestor and Otto von Geldern.

For Junior member —

William W. Fogg, Civil Engineer, of Oakland; proposed by M. Manson, C. E. Grunsky and Adolph Lietz.

For Associate —

Otto Putzker, of Berkeley, proposed by R. E. Bush, E. T. Schild and H. C. Behr.

Mr. John Richards then opened the discussion of the topical subject: "Some Problems in Pumping Fluids," which was fully discussed by prominent members of the Society.

Mr. N. S. Keith suggested a plan of taking the Electrical Society into the Technical Society, and said: "It is very much desired that a union of the two societies take place, and I offer some suggestions that may lead to it. Let the members of the Electrical Society apply for membership in regular form in this Society, and, if it seem desirable thereafter — the membership being something like one hundred, and the science a specialty — they might organize a section of the Technical Society, or otherwise, as may be thought best."

Mr. Keith thereupon made a motion that a committee of three be appointed by the President, for the purpose of having a conference with a similar committee from the Electrical Society, with the object in view of a union of the two organizations. The motion was seconded by Mr. Bestor, and carried unanimously.

The Chairman thereupon appointed as such committee: Messrs. Geo. W. Dickie, John Richards, and D. C. Henny.

The President then stated that it had been announced that the professional papers read at the last regular meeting were still open for discussion, but as the hour had grown late, and as a number of electricians had departed, he thought it best to postpone any discussion of the subjects, *Electric Transmission of Power*, and *Photographic Topography*, until some future time, when the members should be fully prepared to take up these subjects and submit them to a detailed discussion.

Adjourned.

OTTO VON GELDERN, *Sec'y.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME X. No. 6.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

INTER-OCEANIC SHIP-CANAL COMMUNICATION BY THE AMERICAN ISTHMUS.

ITS GEOGRAPHIC AND ECONOMIC RELATIONS TOWARD THE UNITED STATES.

By N. J. MANSON.

[Read July 7th, 1893.]

During the past year, Mr. President, I have expressed through the press some views and opinions upon the subject of interoceanic communication. A few of the members of your Society expressed the regret that one of my articles had not been read before this Society. In accordance with a promise made at that time I appear before you to-night asking your indulgence.

"Commerce loves the sea, but it depends for life and health on the land. It derives its sustenance from the rivers and the basins which they drain, and increases the opulence of nations in proportion to the facilities of intercourse which those nations have with the outlets of such basins. * * * * * *

The three great outlets of commerce, the delta of the Mississippi, the Hudson and the Amazon, are all within 2,000 miles, ten

day's sail of Darien. It is the barrier which separates us from 600 millions of people. Break it down and the Atlantic Coast of the United States and the Gulf of Mexico become the focus of the world's commerce."

It is appropriate that every discourse upon ship-canal communication by way of the American Isthmus should open with a selection from Maury. His name is as inseparably connected with inter-oceanic transit as it is with that of Ocean whose winds and whose currents he mapped and defined. The name of Maury is as intimately blended with a ship canal through Central America as is Humboldt's with Science, Hamilton's with Finance, Webster's with Constitutional Law, Clay's with Internal Improvements directly by the Government, Lincoln's with Emancipation, Jefferson's with Independence.

No man who pretends to be in the slightest degree conversant with the possibilities and the merits of ship-canal communication, via the American Isthmus, and its relation to the United States, can afford to be ignorant of Maury's magnificent report on this question in 1849. He clearly outlined the conditions demanding its construction by the Government in the interest of the producing and consuming classes of our country. His prescience distinctly foretold its far reaching and over shadowing importance to the people of the United States.

Great, however, as was Maury's contribution at that time and in a general way, with maturer growth, more extended waterways, more numerous and better harbors, with a coast line extending thousands of miles upon three oceans, with a Mediterranean Sea whose resources and whose tributaries are the pride of this country and the despair of foreign nations, with the ever-increasing volume of trade, and consequent demand for cheapest methods of transportation, the demand for the construction and ownership of an inter-oceanic ship canal route by the Government of the United States becomes more and more imperative.

Maury's writings upon this great topic were necessarily general. He did not pretend to know precisely the best location for an inter-oceanic canal. He knew in a general way better than any man, the advantages which Tehuantepec offered, which Nicaragua offered, and which Panama offered, but the precise information so much needed did not exist, neither in the libraries of the world, nor in the minds of men then living.

In 1866, seventeen years after Maury's remarkable report to the Government, Rear Admiral Chas. H. Davis, in response to a resolution of inquiry of Congress, regarding data for an inter-oceanic ship canal, replied: "There does not exist in the libraries of the world the means of determining, even approximately, the most practicable route for a ship canal across the American Isthmus." The series of explorations and surveys set on foot by Congress, largely in consequence of this report and strong statement of the truth of the case by Rear Admiral Davis, will enable me to present to the Society tonight a condensed statement of a portion at least of the mass of facts collected by the United States engineers engaged in these surveys, and some fair and legitimate deductions from the facts.

The American Isthmus is for nearly its whole extent a ridge of the Cordilleras. From Tehuantepec, where it joins the expanse of North America, to the Gulf of Darien where it joins South America, it is in length about 1,230 miles. Its width is out of all proportion to its length. It is more essentially an isthmus than any other narrow neck of land on the globe. If we will compare the mean of the widths of the Isthmus, at Tehauntepec, 143 miles; at Honduras, 161 miles; at Nicaragua, 169 miles; at Panama, 47½ miles; at San Blas, 30 miles, they will give for the breadth of the isthmus about one-eleventh of its length. Its lowest elevations above sea level, at possible points of inter-oceanic transit, are at Tehuantepec, 754 feet; at Honduras, 2,000 to 3,000 feet; at Nicaragua, 153 feet; at Panama, 287 feet; at San Blas, 1,142 feet; at Caledonia, 1,003 feet; at the Truando-Atrato, 950 feet; at the Napipi Atrato, 778 feet; at the Tuyra-Peranchita, 808 feet. The last five routes are all so mountainous and elevated as to require tunneling from six to ten miles in length. The entire Isthmus has been called an immense causeway, separating the seas while uniting the continents. It is worthy of thoughtful consideration that while the African Isthmus, Suez, is but the center of the Old Continent, the American Isthmus is the center of the oceans.

The opening of navigation through Suez gave a short route inland for Western Europe to the east of the Old Continent. Should this nation, as a nation, open and render free a strait across Central America, we not only join the oceans embracing our country but we open the two halves of the globe to the enterprise of our people, and there will be accomplished for the people of the United States the most ample and far-reaching achievement of civilization since the creation of the world; or, to quote Humboldt and Maury,

an epoch in the history of the universe will stand distinctly marked, and, it may be added, that should this channel be permitted to be opened in any other way than by a free, an enlightened, and a liberal nation, its natural guardian and custodian, the clock of the world and of civilization will be turned backward one century at least.

We sometimes call to mind the effects of the great engines of civilization, and watching their growth and progress we wonder if they do civilize, we sometimes reflect — who is he who wields them, in whose interest are they wielded, and at whose expense are they wielded? How is it that a mighty corporation, joining to itself a powerful government, shall say the word and a prosperous business and its promoters disappear as the bright buds of summer beneath the withering breath of winter? How is it that this can be done, and its friends and stockholders seize upon that blighted and ruined business, and lo it blossometh again like the rose and enriches the corporation as it impoverishes directly and indirectly the people.

This is because of the ignorance, the indifference, and the corruption of the people themselves primarily, and of their rulers secondarily, and thirdly it is because there exist in our midst men most powerful and corrupt who purchase the rights, the powers, the duties and the laws of the Government itself, so that the purchasers may use this purchased legislation to enrich themselves at the expense of the people. When the Government, through ignorance or through corruption, by legislative enactment has abandoned its people, its policy, its principles, and its purse, what but impoverishment and ultimate enslavement must be the fate of law-loving and law-abiding citizens?

If there be any question from the contemplation of which I would shrink with peculiar horror, it would be that of the great mass of the American people sunk into a profound apathy on a subject of overshadowing national importance; on the subject of free natural resources; on the subject of inter-oceanic ship-canal communication; on the subject of the freedom of the empire of the sea. Such a spectacle would be more portentous to the eye of intelligent patriotism than all the monsters of the earth and fiery signs of the heavens to the eye of trembling superstition.

If the people can be indifferent to the fate of such an enterprise as the Nicaragua Canal. If the people can be indifferent to the fate of an enterprise affecting so profoundly their industries and their commerce they would be unworthy of freedom, and if there be such a power as that of political galvanism, I invoke its application to rouse them from their fatal lethargy.

The rousing of the people to meet the exigencies of this question is as essential to the health and energy of the body politic as circulation of the blood is to the health and energy of the natural body. If a purchased, an insidious or delusive press cause the people to be indifferent in matters of paramount and far reaching national moment, and thus destroy their legitimate influence, you communicate a morbid violence to the efforts of those who would assume the control of such affairs, and so surely as action and reaction are forces known to be equal, so surely will political revolution restore to its just place the power and dominion of the people in their national affairs. Keep the people quiet, peace, hush, be still! Such are the whispers by which the people are to be lulled to sleep in the very crisis of their highest affairs. Peace? 'Tis death! Take away all interest from the people in such a matter as the Nicaragua Canal, turn it over to a private corporation with a Government subsidy, and the empire of the sea is lost to the American people, and their commerce is no more.

In the report of the Senate Committee of Foreign Relations, submitted by Mr. Sherman, Dec. 21, 1892, and accompanying Senate Bill 1218, pages 1 and 2, it is attempted to be maintained that the corporation in possession of the Nicaragua route is a public and not a private corporation.

There is no question in point of law that unless the whole property is owned by the Government the corporation is a private, and *not* a public corporation.—2 Kent's Com. 305–6; 9 Wheaton 907; 9 Cranch 43-52; 4 Wheaton 636; 1 Call 164; 1 Minor's Institute (503) 548; Ang. & A. on Corp. § 14, 23, 24, Dillon on Munic. Corp. § 52, 53, 54, 55.

"It is a sound principle of law that when a government becomes a partner in a trading company it divests itself, so far as concerns the transactions of that company, of its sovereign character, and takes that of a private person."—Marshall, C. J., 9 Wheaton 907.

It will appear from an examination of the above authorities that the ground upon which it is held that a corporation is private, and not public, unless the whole property therein is owned by the Government, is "there exists a contract between the Government and the private parties or stockholders, which contract cannot be impaired." Section 7 of Senate Bill 1,218 provides for such contract, and for *the acceptance of the provisions of this act by a resolution of the stockholders of said company at a meeting duly called and held.*

The provisions of the Bill itself by providing for the contract, between the public on one hand and the private stockholders on the other, settles beyond all dispute the question whether this be a public or private corporation. It is private.

The United States will consequently be compelled by its own courts to take the nature of a private company so far as this great enterprise is concerned, and commit itself to the contract between that private company and the States of Nicaragua and Costa Rica, and to the policy of that corporation, which policy is not to operate the canal for the interest of the public, low tolls, but in the interest of the private stockholders, high tolls, or all the traffic will bear.

This clearly follows, no matter what proportion of the stock is owned by the United States, nor how many members it may have in the Board of Directors. When we furthermore take into consideration the inhibitions placed upon foreign governments in the two concessions to the corporation from Nicaragua and Costa Rica, it will be seen that the industrial and producing classes of this Government, whose commerce is the object of this transaction, will be preyed upon to the ultimate ruin of those classes and of their commerce.

The language of the Bill makes the corporation private. The committee in their report labor to show that the corporation is public. I submit the question of motive to those who are best acquainted with the ways of the Senate Committee.

The able committee of foreign relations of the Senate stand before the people of the United States their very fame imperiled, if having in their report represented this corporation to be a public corporation, one acting and created for the public good and welfare, they, in their bill or enactment, use language which makes that corporation private, or one acting for its own emolument at the expense of the people and of their commerce. If the committee be sincere, they must make their enactment conform with their report. They must make the corporation at Nicaragua a public corporation; its entire ownership must be in the Government.

The principle announced in the decision of Chief Justice Marshall has caused the third house, commonly called the lobby, to become the Senate, the House of Representatives, and the President of the United States. The third house is the law-making power of the United States, if not fully so it is fast becoming so. Those matters which are, and should be, under the decision of Marshall strictly and exclusively governmental, are sought to be made joint enter-

prises of Government with avaricious and greedy private citizens, who thus seek to cause the Government to lose its sovereign character in order that it may partake of their avarcious and greedy nature, and make all national legislation pertaining to powerful instruments of civilization most powerful instruments of oppression, of high rates of toll, and high freights and fares. Because of the perversion of the duties, the powers and the laws of the Government, and consequent corruption and oppression, people lose confidence in Government itself, and even in one another.

"Montesquieu has held that a despotic monarchy is not so bad as a corrupt republic, this opinion does not rest upon theory merely, it is sustained by the world's experience in every age of which we have authentic history. Corruption is the worst form of oppression, for it is not only impoverishing to a people, but it leads to general demoralization and criminality; to subversion of all authority, and to anarchism. Despotism may crush, but corruption debases the spirit of a people. If long tolerated, corruption of officials and leaders will extend to and involve the body of the people, and there is no relief from its malign influences except in revolution and bloodshed."—*The Californian* for June.

The long continuance of corruption and consequent oppression will cause the very principles of self government to disappear, and the cherished plan of the fathers, "like the insubstantial pageant of a vision," will pass forever from our sight. Let us bear in mind that monarchy has succeeded republics because the latter have become corrupt.

The Government of the United States, realizing the full importance of an inter-oceanic canal, and acting upon the report of Rear-Admiral Davis, sent into Central America its most experienced navigators and engineers, and it expended, in its surveys and explorations, according to De Lesseps no less than $5,000,000.—*North American Review*, Vol. 130, page 1.

A general attack, in an engineering way, upon all the possible lines of canal transit seems to have been determined upon by Congress.

I. In the first place, Congress caused an instrumental reconnoissance of the Isthmus of Tehuantepec to be made by Captain Shufeld in 1872.

II. In the same year Congress caused to be made, by Commander E. P. Lull, U. S. N., an examination, survey, and definite instrumental location of an inter-oceanic canal route from the vicinity of Graytown, via Lake Nicaragua, and thence via the rivers

Medio and Grande to Brito on the Pacific Coast. As supplemental to this survey some preliminary observations were made in 1872 by Commander Chester Hatfield, U. S. N.

III. It caused to be made an examination and instrumental survey of an inter-oceanic canal route from Navy Bay to Panama by Commander E. P. Lull, U. S. N., in 1875.

IV. It ordered and caused to be made examinations and surveys from the Gulf of San Blas toward the River Chepo by Commander T. O. Selfridge, U. S. N., in 1870, and caused reconnoissances to be made from the waters of the Chepo toward the Gulf of San Blas by Commander E. P. Lull, U. S. N., in 1875.

V. Under its direction several tentative instrumental surveys in the vicinity of Caledonia Bay, across the Cordilleras, were made by parties under the direction of Commander T. O. Selfridge, U. S. N., 1871.

VI. It caused a barometrical reconnoissance to be made of the "DePuydt Route" by way of the Tenala River, between the Tuyra and Atrato, by a party under the direction of Commander T. O. Selfridge, U. S. N., 1871.

VII. Tentative Instrumental lines by the so-called Gorgoza route, from the east coast by way of the Atrato Caracica and Peranchita Rivers, from the west coast via the Tuyra and Cué Rivers across the divide, were made by parties under the direction of Commander T. O. Selfridge, U. S. N., 1871.

VIII. An instrumental examination was made of what is known as the Truando Route by Lieut. Michler, U. S. A., and Craven, U. S. N., 1856-7. This survey was supplemented by an instrumental reconnoissance of the Napipi and Cuia Rivers, including a reconnoissance of the Atrato River to the town of Quibdo, by parties under the direction of Commander T. O. Selfridge, U. S. N., 1871-1873.

IX. It caused a tentative examination and definite instrumental location to be made of an inter-oceanic canal by way of the Napipi and Doguado Rivers, by Lieut. Fredrick Collins, U. S. N., 1875.

X. Congress caused the work of Commander Lull, at Nicaragua, in 1872-3, to be supplemented by parties under the direction of Mr. A. G. Menocal, C. E., U. S. N., in 1880-81 and 1885-86, the nature of this Government work of Mr. Menocal being an instrumental survey and definite location of an inter-oceanic canal via Lake Nicaragua, including the location of the necessary dams,

locks, etc. This later work of Mr. Menocal's being subsequent to all the Government surveys was made after the Government of the United States had determined, through what is sometimes called its high commission, that the Nicaragua route was the most feasible of all the routes, and the survey was made with the express object of carrying out the provisions of the Zavalla-Frelinghuysen treaty. (Government Construction and Ownership of the Nicaragua Canal). The main provisions of this treaty will be adverted to later.

It has been said of these various routes by Professor Nourse, one of the very highest authorities on this subject:

I. That Tehuantepec, though possessing large natural and political advantages, requires 140 locks to overcome an elevation of 754 feet, and a feeder 27 miles in length.

II. That the Panama Line is the shortest of all the routes, not involving a tunnel. It is liable to the heaviest of tropical rains, falling in the Culebra section upon a trench nearly 500 feet in depth. It is also liable to the sudden rise of the River Chagres. The climate of Panama is notoriously a physical obstacle, which must be considered in any estimate of the advantages and disadvantages of the route.

Lieutenant Brainard, U. S. N., who was at Panama in the early part of this year, in a communication in the *Scientific American* of February 25, 1893, has this to say of the present condition of that enterprise:

"The original plan was a failure because of inadequate knowledge of the country, incomplete surveys, wrong estimates, ruinous sub-contracts, and last, but not least, corruption. The engineering difficulties of the new plan may be mentioned as the Culebra cut, the Gamboa dam, and the control of the Chagres River, the most important of these is the dam, which is to contain 3,000,000 cubic yards of material. Those in a position to know, and well informed men generally, place the probable cost of completion at not less than $125,000,000, and the time at not less than seven years."

Lieutenant Brainard represents the machinery in excellent condition, tow-boats, launches, lighters, etc., are housed in; important machinery is protected and preserved by careful keepers. The excavated portions of the canal are said to be filling in to some extent, though not to an extraordinary degree, nor to the extent that was expected by the projecting engineers.

The receiver, in whose hands the canal property now rests, is said to be expending about $35,000 per month in preserving the plant. He adds that the Columbians believe in the ultimate success

of the canal, that the Columbian Government will do everything in its power to help the Canal Company to its feet, and that in case work is resumed it will be on the plan of a lock canal.

III. We come now to the San Blas route. Of this route Mr. Nourse says, though the shortest of all the proposed routes, the distance from tide to tide being only 19.5 miles, and although the harbors at both termini are exceptionally good, it must be eliminated from the problem of canalization by its demand for a tunnel from 7 to 8 miles in length.

IV. The Atrato-Napipi route, fully surveyed by expeditions under Commander Selfridge and Lieutenant Collins, which were supplemental to the extensive surveys under Michler, Craven and Trautwine, must also be eliminated, in the opinion of Mr. Nourse, by reason chiefly of a like demand for a tunnel. The late eminent civil engineer Trautwine estimated the cost of canal by this route at from 300 to 400 millions of dollars.

Lieutenant Jno. T. Sullivan, in his observations upon the report of Major Walter McFarland, who had been sent by the Canal Commission to report upon the comparative merits of the Napipi and Nicaragua routes, says of a tunnel in such a structure as this: "Even if it could be successfully carried out so far as its construction is concerned, it would still be liable to many objections. A convulsion of nature might in a moment destroy the whole work. A new system of towing vessels would have to be devised, and it would be quite a problem to deal with smoke and gases."

V. The Nicaragua Route. This route has, as a grand interior basin and feeder, a lake of 2,600 square miles (4½ times the area of the Bay of San Francisco). It has a more healthful country, and more abundant supplies for construction than any other route. Its supply of native labor is large, it is better than that of any other route. In works of magnitude in tropical countries this is a most important consideration. Except the Tehuantepec route it is nearer by 700 miles to the United States and its commerce. Its termini lie without the equatorial belt of calms, and if those termini can be built up and restored they will be easily accessible to sailing vessels.

In a letter by Maury, the great authority on this subject, which was read by Captain Pym, of the Royal Navy, before the British Association, at Sheffield, Com. Maury said: "Panama has the advantage of land transit, Nicaragua has the advantage in winds, terminal points, and climates. I have spoken about the calm belt about the equator, Panama is within its range. I have known ves-

sels going to or from Panama to be detained by them for months at a time." He cites a case where the British Admiralty found it necessary to have one of their vessels towed by a steamer through this calm belt, and carried 700 miles out to sea before she could find a breeze. The disadvantages of the Nicaragua route are its locks, its dams, its length, its heavy rainfall on the Atlantic coast in the vicinity of Graytown, its absence of terminal harbors. I do not mention liability to volcanic disturbance, for not only is the *general* effect of volcanic disturbance frequently overrated, and its permanent influence comparatively local, but high authority can be found for the proposition that in the vicinity of any proposed canal through Nicaragua volcanic force has probably exhausted itself. With regard to earthquake disturbance it may be stated that buildings of brick and stone have stood for many years within a few miles of the line of the located canal.

It has been my purpose to lay before the Society the main features of the various Isthmian routes so that it may be able to form a general judgment of the comparative merits of all. I have dwelt at no great length upon the merits of the Panama Route, nor at all upon the merits of the Eads ship canal at Tehauntepec. They may both be practicable and highly meritorious plans, but I do not consider it necessary at this time to farther occupy the time of the Society with these possible undertakings.

I will state, generally, however, in the language of Professor Nourse, in order to enable the Society to form its opinion, that: "To meet the requirements which commerce, supported by all the advanced appliances of this day imperatively demands, the transit must offer the allurements of a full, uninterrupted, safe and speedy transportation. It must be a water highway, through which the largest sea-going vessels, with a tonnage of even 6,000 or more, may pass without breaking bulk; and, it must be remembered, that all experience proves the justice of the statement that railways and canals are supported by the carriage of different species of merchandise. Products of great value and small bulk voluntarily selecting the more rapid channel of the railway, while others choose the maritime route."

Having now passed in review the salient features of the American Isthmus, and drawn briefly your attention to the various possible routes, I pass to the consideration of that route to which the expensive, independent and extended surveys of the Government were indispensable to enable the United States Canal Commission,

consisting of General A. A. Humphries, Chief of Engineers, U. S. A.; C. P. Patterson, Supt. U. S. Coast Survey, and Daniel Ammen, Chief of the Bureau of Navigation, to form and base their unanimous opinion and report, "that the Nicaragua route possesses, both for construction and maintenance of a canal, greater advantages and offers fewer difficulties from engineering, commercial and economic points of view than any one of the other routes."

But before proceeding into minute details of the essential features of this route, I wish to note the geographical and physical relation which our own country bears to this route, and to pass in brief review the nature of our Government, the degree of enlightenment and liberality which marks our growth, the character of our laws, the spirit of progress pervading our institutions, the characteristics and genius of our people, their history, their deep-seated hatred of every form of oppression, their in-born love of freedom.

Here a boundless field, by no means perfect, opens to our view, but I can only say that however interesting and instructive an investigation of these several topics may prove we must for to-night content ourselves with a glance at the *effects* of our institutions, knowing full well that conclusions based altogether upon the material effects which have been wrought out by our civilization, while to some extent fallacious and delusive, yet in the main they will form a not unfair criterion of the degree of advancement and of civilization, which under God and our system of Government we may have attained.

It is then in this connection that I invite the attention of this scientific and interested assemblage to the contemplation of the map of the world, and of the necessary relation which that country, whose voice is the harmony of this Western Hemisphere, bears to the rest of the world.

Bordering upon the Gulf of Mexico to the northward lie the great States of Texas, Louisiana, Mississippi, Alabama, and Florida; while on the Atlantic Coast, stretching from Main to Florida, lie the original thirteen Free and Independent States, the centers of our population, the marts of trade, the homes of wealth. Far away to the westward lie the great cities of Minneapolis, St. Paul, Omaha, Chicago, St. Louis, Detroit, Cincinnati, New Orleans,—the jewels of the Nation. In very truth the jewels of the Nation. For more than to any single thing their growth and prosperity is due to the fact that the nation itself has kept open the great water highways of commerce upon which they lie. The people have never

permitted the waterways of the Great Lakes or of the Mississippi to fall into the hands of a private corporation, whether it be subsidized or not.

In this princely domain, this great valley of States, we have a development of such splendor that under its steady and serene ray, the original thirteen States, the wealthy East shines with the pale magic of reflected light. Through these mighty arteries, and their numerous veins, in strengthening tides flows trade, the calm health of nations. Still further westward, on the shores of the Pacific, lie the great States of Washington, Oregon and California, and the immense northwestern Territory of Alaska, whilst between the Mississippi and the Pacific stretches a domain whose magnificence under wise and wholesome laws will prove the just pride and boast of every American. Such, hastily and rudely outlined, is the country whose resources and whose people are profoundly affected by any enterprise in the nature of a ship canal at Nicaragua.

Turn now once again to the map of the world. To the prompt and advantageous interchanges of ocean commerce between nations nature has opposed in each hemisphere an isthmian barrier, the one the African Isthmus at Suez, the other the American Isthmus. Each is near the center of the land in its hemisphere; each is central to the population in each hemisphere; each is favorably situated with reference to the winds and currents of the ocean, and each becomes as a consequence the outlet and inlet of ocean commerce.

The Suez Canal was completed by a private corporation in November, 1869. It was constructed by those who had no intention of using it themselves, and whose principal intention was to enrich themselves at the expense of the many.

How well they succeeded the appended table will show. Your attention is now called to the fact that since the Suez Canal was built, the producers and consumers of the world have paid for its construction more than twice over, and if interest be added to the receipts of each year, they will have paid for it some four or five times over, and in all human probability they will pay for it twenty times over.

With such an object lesson will the American people repeat this wrong, this crime upon humanity? Well might one of England's great statesmen exclaim: "Go see the world, my son, that you may see with how little wisdom mankind is governed."

TONNAGE AND RECEIPTS OF THE SUEZ CANAL.

The receipts and tolls of the Suez Canal are from the official table, from Nourse on the Maritime Canal of Suez, from the Year Book of Statistics, and from Mullhall's Dictionary of Statistics.

Year.	No. of Ships.	Net Tonnage.	Receipts.
1870	486	436,609	$ 1,031,865
1871	765	761,467	1,798,746
1872	1,082	1,160,743	3,281,513
1873	1,173	1,367,767	4,579,465
1874	1,264	1,631,650	4,971,476
1875	1,494	2,009,984	5,777,260
1876	1,457	2,006,771	5,994,599
1877	1,663	2,355,447	6,554,868
1878	1,593	2,269,678	6,219,645
1879	1,477	2,263,332	5,937,212
1880	2,026	3,057,421	8,364,179
1881	2,727	4,136,779	10,935,238
1882	3,198	5,074,808	12,681,918
1883	3,307	5,775,861	13,702,413
*1884	3,284	5,823,977	12,494,002
1885	3,624	6,289,788	12,320,819
1886	3,100	5,728,319	11,587,707
1887	3,137	5,901,030	11,484,582
1888	3,440	6,606,570	12,864,893
1889	3,425	6,724,021	13,268,038
1890	3,389	6,824,390	12,994,799
1891	4,207	8,552,590	15,503,874

*From the year 1884 to the year 1891, inclusive, the gross tonnage only was given by the above authorities. The gross tonnage was reduced to net tonnage by taking 70 per cent. of the gross tonnage, which Mullhall states to be the proper reduction to be applied. From 1884 to 1891 the net tonnage is only thus approximately correct. The net tonnage for the preceeding years is absolutely correct.

This is the enslavement, not only of men, but of nations and of governments. Not only is it the enslavement of the users of the land, but of the users of the seas. Is it possible that in any government calling itself civilized, avarice and greed are allowed to become such powerful passions in the few that the rest of the world shall be legally placed in their mighty grasp?

In a recent monograph on the subject of strict and entire Government ownership of the Nicaragua Canal, it was shown that Government ownership and construction of the Sault St. Mary Canal had saved in a single year to the producers and consumers of the United States, the sum of $50,000,000, and that by reason of the keeping open of the water highway of the Great Lakes by the Government, there was saved in one year, to the producers and consumers, the enormous sum of $135,000,000. This was the direct saving to the people. The indirect saving was not discussed; it is equally astounding. No man can estimate the direct and indirect saving to the people from the keeping open of that single system of water communication — the Mississippi and its tributaries. It is beyond computation, and it may be stated as a general proposition, that while the great agencies of communication and of transportation are free, or are conducted not as mere speculative and oppressive agencies, nations will in truth rise; and if, on the other hand, they are conducted as mere instruments for obtaining all the traffic will bear, nations will in truth decay, and these propositions are susceptible of both inductive and deductive demonstration.

At this date it is hardly necessary to remind you that the Government of the United States would have the full constitutional power to construct and own the Nicaragua Canal, and operate it in the interest of its people, in the same way that it has improved the Mississippi and the Great Lakes. Indeed, the very convention which framed the Constitution of the United States, by a vote of eight to three denied the power to the General Government to grant a charter to a private corporation for the purpose of cutting canals in cases in which the authority of a single State would be insufficient.—(Madison Papers 1576.) And the same reference will show that it was the intention of the framers of the Constitution to grant the power to the General Government to do directly for the people that class of work.

The direct improvement by the Government, of the harbor of Pago Pago, in the Samoan Islands, and Pearl Harbor in the Hawaiian Islands; the purchase known as the Louisiana purchase,

of Florida, and of Alaska, all furnish ample precedent for the direct action of the Government itself at the Nicaragua route, either by purchase or under treaty with the Nicaraguan Government.

At one time there were a few who thought the General Government would become too powerful or too corrupt if it directly undertook matters of internal improvement. To those I wish to say that they are repeating the arguments of the private speculators. Your Government has become infinitely more corrupt through going into partnership with private corporations, and vastly more injurious and oppressive to the great body of the people from this single circumstance than from all others combined. If Government legislators were not allowed to sell everything in sight under the name of a federal franchise, and pocket the proceeds, the body of the American people would have vastly more than they have at present, and an era of congested wealth in the hands of a few would not be upon us.

The power in government of making internal improvements for the benefit of the people is not a power in any country dangerous to liberty. On the contrary, it is the one power, of all others, in a civilized country which, when exercised by government, is the surest guarantee of liberty, and the real power which prevents the enslavement of the masses of the people by the very strength and knavery of our alleged civilization. It is a power resident in the Government which should protect the people from being turned over, bound hand foot, to the soulless and the avaricious, to the purchasers of legislation. It is that power which if exercised strictly and entirely by the Government, is for the general welfare and is truly civilizing.

Those powers which are dangerous to liberty are directly and specifically granted to the General Government of the United States. All admit that the power of levying taxes, of raising armies, of equipping navies, and of carrying on war, are specifically granted to the General Government.

The purse and the sword are the only instruments that are wanted or can ever be employed for the accomplishment of any ambitious purpose. These having been abandoned to the discretion of the General Government, with what propriety can we apprehend danger from the power to construct a sub-treasury, lay out a canal or road, or build a bridge.

Some one has said: "this would be about as unreasonable as if a lady who had granted to one of her admirers the name and essen-

tial privileges of a husband, should afterwards consider it hazardous on the score of delicacy to accompany him on a journey, or take his arm in a promenade."

Did Cæsar, Cromwell, or Bonaparte subvert the institutions of their respective countries by laying out a road or canal in the interest of the people? Did they subvert the institutions of their countries by building up its commerce or by causing general and individual prosperity?

It has been reserved for a people living under the form of a free government, to witness almost the subversion of their institutions by a power vastly more dangerous to liberty than that of Cæsar or of Cromwell, because it is more insidious and least understood, and more relentless in its grasp upon the people, because it is unrestrained by either the law or the press. Corporate power is fast becoming the law; corporate power is fast becoming the press.

As to the international questions involved in this discussion, and particularly as to the Clayton-Bulwer treaty, I refer without reading, to a monograph by myself on Government Construction and Ownership of the Nicaragua Canal, page 23 *et seq.*

GEOGRAPHICAL AND PHYSICAL FEATURES OF CENTRAL AMERICA AND OF NICARAGUA.

Chief Engineering Difficulties Encountered in the Canalization of the Isthmus at Nicaragua.

The States of Central America do not derive their highest importance from their commerce, but rather from their great natural resources, and from the fact that through their territories nature placed the shortest lines of communication across the continent. Here Columbus placed "the Gates of Ocean."

The Republic of Nicaragua, one of the five states of Central America, lies between the States of Costa Rica, on the south, and Honduras, on the North. It extends from ocean to ocean, and is in north latitude between the 11th and 15th parallels. It has a population of about 375,000 people, of which about 50,000 are pure whites, mostly of Spanish descent, the remainder are Indians, negroes and mixed races. Spanish is the language of the country.

The great geographical feature of Nicaragua is the depression between the Cordilleras and Coast Range of hills. This depression is larger than the Lake of Nicaragua, it is about 180 miles in length

by 70 in width. In its lowest depth are found the Lakes of Nicaragua and Managua, and on its sides are the narrow but fertile plains of Leon and Conejo.

The mean elevation of the surface of Lake Nicaragua is about 106 feet above the mean level of the oceans. Its greatest depth is said to be 150 feet, or about 44 feet below sea level. Its length is 110 miles, and its greatest width about 40 miles. It covers an area of 2,600 square miles. It is the collecting and distributing reservoir of a watershed of about 8,000 square miles. This lake then serves to collect and gradually distribute through its single outlet, the San Juan River, the heavy rainfall, which might otherwise rush in a torrential stream through this river, the lowest pass or outlet from the lake to the Atlantic. The lake which is its source is nature's solution to the problem which De Lesseps failed to solve at Panama, the control of the head-waters of a river often swollen and engorged with heavy tropical rains. The San Juan, between its source and confluence with the San Carlos, near Ochoa, rarely rises over ten or twelve feet. The Chagres in its upper reaches rises more rapidly and to a greater height.

The San Juan is a stream of considerable volume, 120 miles in length, from 100 to 400 yards in width, with a fall in its whole length of 106 feet, and a fall in the first 65 miles from the lake of about 56 feet. While its upper reaches are from ten to twenty feet in depth, its lower reaches are shoal. It has several heavy rapids, known as the Machuca, the Balas, the Castillo, and the Toro Rapids. These rapids, excepting the Castillo, are all traversed during the rainy season by steamers of light draught. Careful gauges of this river at its lowest stage, between the lake and Toro Rapids, by Lieut. Miller in 1873, show a minimum flow of 11,390 cubic feet per second. Colonel Childs estimated the discharge with full lake in the rainy season at 18,059 cubic feet per second. The mean is 14,724 cubic feet, or 1,272,153,600 cubic feet per day. See Report of U. S. Nicaragua Surveying Party 1885-6, and Report of Commander Lull 1872-3.

The country east of the lake is, much of it, not only unsettled but unexplored. It is covered with a dense tropical growth of entangled vines, underbrush, and trees which the eye cannot penetrate, and which can only be entered after constant work with ax and brush hook.

Until the Government Survey of 1885, made with the object of carrying out the provisions of the Zavalla-Frelinghuysen treaty,

(Government Construction and Ownership) no exploration or survey of the direct route from Ochoa to Greytown had been made; previous surveys having followed the lower windings of the San Juan. It had been pointed out, however, as early as 1876, and again in 1880, that to the north and east of Ochoa lay probably the best route for the canal.

To the westward of the lake the country is open and well understood, there are frequent roads, and the Government of the United States has often surveyed the route. Within a few miles of the located canal are villages and towns. The climate west of the lake may be considered healthful. The two seasons are the wet and dry, The wet season there begins about the 15th of May and ends about the 15th of December. Mr. Menocal states that "during the other six months of the year practically no rain falls." He placed the rainfall for the year 1873 on the west side of the lake at fifty-six inches.

The climate east of the lake, and in the vicinity of Greytown, is unhealthy, yet the strong easterly winds which prevail during much of the year render the climate at least bearable by the natives. The rainfall at Greytown has been placed at between 300 and 400 inches annually. The precipitation is said to decrease as the lake is approached. As to the healthfulness of this eastern section Mr. Menocal says: "During the four months that we remained in the country, of which more than three months was of constant arduous work, exposure and privation, no officer of the party was ever affected by sickness due to climatic causes, and as for the natives attached to the party, their only ailments were a few bruises."—Rep. U. S. Surveying Party, 1885, Page 38.

Mr. G. W. Sherwood, C. E., who was for a year or more engaged as engineer on the Nicaragua Canal, in an article in the *Riverside Daily Press*, of June 28th, 1892, states that the country in the vicinity of Greytown is subject to an annual deluge of 400 inches.

"'The proposed route extends from Greytown, on the Carribean Sea, to Brito, on the Pacific, its total length is 169.8 miles, of which 38.98 miles will be excavated canal, and 130.82 miles navigation by Lake Nicaragua, the River San Juan, the basin of the River San Francisco, and through some six locks. The lake will be connected with the Pacific by a canal, and with the Atlantic by slack water navigation in the River San Juan, by a short section of canal from the River San Juan to the basin of the River San Francisco, navigation through this basin and by a canal from the eastern end of this basin to the Carribean Sea."—Report U. S. Nicaragua Surveying Party, 1885.

The first obstacle which engineering skill encounters on the Nicaragua route is the improvement of the harbor of Greytown. Professor H. Mitchell, of the United States Coast Survey, who made the report upon this harbor in the early seventies, has this to say of its formation:

"The harbor of Greytown was originally a re-entrant angle or cove, lying between the delta of the San Juan River and the adjacent coast to the northwestward. Near the head of the cove there entered an offset of the San Juan, which formed a subsidiary delta of its own within the cove.

The cove opening to the northward was in course of time converted into a lagoon by a mole of sand driven across the mouth by waves from the northeastward, which swept past the outer shore of the main delta. It became a harbor, easy of entrance and perfect in shelter, at the intermediate stage when the mole had reached within a couple of miles of the main shore to the westward, at which time the channel way from the basin to the sea was in no wise dependent upon the outflow from the lower San Juan, nor upon the tides, but was simply an avenue, not yet encroached upon, whose bed was the original floor of the ocean.

It was not until the mole had nearly crossed to the opposite shore that the river outflow and the tides began to act upon the bed and banks of the outlet resisting the absolute closure of the basin. Opposed to this view of the case is another, very different in character, and adopted by many engineers, it alters the question of practicability or restoration, or, at all events, modifies the plan of improvement." * * * * * * * * *

"The sand bar (Punta Annas), which now separates the Greytown basin from the sea, is a part of the delta of the lower San Juan River, and is formed from materials swept down this river in floods. In former times the lower San Juan received a much larger proportion of the waters of the parent stream, and was able to maintain a grand opening to the sea, but recently the main river has chosen to send its waters to the sea by the Colorado, and in this way the lower San Juan has been deprived of the power of pushing its debris into the sea, and thus maintaining a ship channel through the Puntas Annas."

Lieutenant Brainard, who visited Greytown in the early part of this year, in his article in the *Scientific American*, of Feb., 25th, 1893, says substantially that a pier nearly normal to the coast line has been built about 1,000 feet, and that to the eastward of the pier the shore line has made out about 700 feet; the channel to westward does not get as much scouring as was hoped for, and that the breakwater will probably have to be continuously extended, and constant dredging will be necessary to keep the entrance to the harbor in passible shape. There is ordinarily, he states, about eight feet of water on the bar.

In an interesting and very able paper on "Harbors on the Pacific Coast," appearing in the March number of *Industry*, 1892, by Mr. Otto von Geldern, C. E., referring to wave action as the destroying force of Pacific Coast harbors, he says:

"The tendency of the wave action of the ocean is to *close* and *obliterate* an indentation or recess in the shore line, the littoral current being the agent that directs the course in which the sands are built up. It is the tidal influence that *opposes* this destroyer; the amplitude of the tides and the area of the tidal basin being the principal factors that constitute the *conserving force* of the harbor, which keeps open an outlet and makes the inner basin accessible from the ocean. The watershed from the land is *inconsiderable* when compared with the semi-daily recurring tidal drainage, and adds little to the efforts of our harbors to keep free. This is more particularly the case in the southern harbors, but even on the northern coast the land drainage is of secondary importance, in so much as the tide remains in every case the main conserving element. Colonel Mendell has stated that the great Columbia, with a flood discharge of a million cubic feet per second, might not be able to maintain throughout the year the entrance depth required for deep-sea vessels.

It is evident that the product of tidal rise and area of basin; *i. e.* the tidal prism, and the time of its discharge through a given area of the gorge, will determine the velocity of the outflowing current, whose scouring effect is brought to act upon the sandy barrier thrown up from without, and that these elements constitute the gauge or measure of the available channels."

In addition to the scour there is to be considered the greater energy of the daily-intruding flood, whose importance has been only too often overlooked." * * * * * * *

"It is the duty of the engineer when planning an improvement, to study and weigh carefully the physical factors that enter into his particular case; to observe the littoral movements and direction of the flood action, and to measure the elements of the conserving force, so as to determine in what manner the latter may be encouraged to produce the best effect upon its bar-building antagonist; and it goes without saying, that every rational improvement of ocean bars must be based upon a sound knowledge of the natural forces that cause them. We know that experimental works, carried on without a thorough investigation of the field, have not only resulted in wasting large amounts of money, but have been the cause of injuring, instead of bettering, existing conditions. The problem is always an intricate one, and although we may be thoroughly acquainted with its general principles, there are many factors due to local causes that only too often elude our observation.

The profession is indebted to Mr. Lewis M. Haupt, a very prominent American civil engineer, for agitating and creating discussions of vital importance in this direction. He suggests remedial measures in accordance with modern theories, that are original with him as

applied to meet his conditions. Without going into any details, the main points to be observed in an improvement seem to be: 1st. That the flood be allowed to enter freely, in order to insure a full tidal prism for the work of the ebb. 2nd. To place a barrier against the material brought by the flood action or littoral drift. 3d. To create a harmonious action of the ebb currents, and to concentrate their energy upon the weakest point of the bar. It may here be mentioned that all mechanical means to deepen *sand bars* on the sea coast, such as dredging or blasting, carry with them the most *ephemeral* results, and are, indeed, a useless expenditure of time and money."

As the tidal range at Greytown is only about eighteen inches, how important it becomes to make this harbor entrance the subject of the most thorough investigation and study. It is the key to the Nicaragua problem of canalization. The most scientific men that we have should study its conditions carefully, and furnish us a report as to its practicable permanent restorement.

THE EASTERN DIVIDE.

The rock cut through the Eastern Divide is probably the most expensive and difficult undertaking on the entire work. This cut is seventeen miles from Greytown. Its length is nearly three miles. The average depth of the cut through this distance is 149 feet. The width on the bottom is 80 feet, and the slope $\frac{1}{2}$ to 1. The material is estimated as: solid rock, 7,760,312 cubic yards; earth, 771,800 cubic yards. The cost of this cut is estimated at $11,982,938. The locality is well drained, and stated to be healthful. Mr. Corthell has shown that the cross section here is not large enough. The rock cut in the Manchester Ship Canal is 120 feet on the bottom.

THE OCHOA DAM.

After the Divide, the dam at Ochoa, thirty-two miles from Greytown, and about three miles below the confluence of the San Carlos and San Juan rivers, is perhaps the most difficult undertaking. The details of this dam are not final. It is 56 feet high (above the then surface of the water, April, 1885); 1,255 feet in length on the crest, with an average depth of foundation estimated at 20 feet below the then surface of the water. This foundation will probably have to go much deeper. The original plans of the Government engineers contemplated a dam of concrete. Subsequent suggestions are to the effect that the stone from the Eastern Divide might be dumped into the bed of the river, and a rough rock structure built up which sediment from the river would in course of time render sufficiently tight to hold enough water.

It is quite evident from the profiles of the river bed, that if the dam should be given an additional height of 8 or 9 feet, it would give the requisite depth (30 feet) throughout the channel of the San Juan, and obviate the necessity of rock blasting under water in its bed. This, however, would increase the lift of the locks on the Pacific and Atlantic sides, and would, moreover, so raise the level of Lake Nicaragua, that the plains along its shores would be to a considerable extent flooded. Embankments along the San Francisco would also have to be raised correspondingly.

THE LOCKS.

These are concrete structures 650 feet long by 70 feet in width. They have a lift of from 30 to 45 feet. They are features in themselves. The supply of water for thirty-two double lockages per day is estimated at 132,000,000 cubic feet.

THE HARBOR OF BRITO.

This harbor is to be constructed. It will require extensive breakwaters. The stone is readily obtainable from the channel of the canal.

THE IMPROVEMENT OF THE SAN JUAN.

This consists principally of rock blasting under water. Whether it would be practicable to divert so large a stream as is the San Juan, even during the dry season, by first constructing the channel of the canal to the Pacific, and with a small temporary dam in the shallowest part of the San Juan, shut off the water and expose the bed of the stream for the work of blasting, can be readily determined with all the facts before the engineers. The lowest gap in the range of hills between the Lake and the Pacific is 153 feet above the level of the ocean.

ESTIMATES OF COST.

The following is the recapitulation of cost, by the Government's chief engineer.

Recapitulation. Western Division.

Excavation and embankment	$8,486,292 00
Diversion of Rio Grand and Rio Lajas	1,870,447 00
Other auxiliary work	753,329 00
Locks	4,762,480 00
Harbor of Brito	1,611,500 00
	$17,484,048 00

Recapitulation. Middle Division. Lake to the East Divide.

Lake Nicaragua	$379,520 00
Rio San Juan	3,068,791 00
Valley of Rio San Francisco	1,112,413 00
Dam across the San Juan at Ochoa	1,858,975 00
Embankment at Ochoa	45,577 75
Embankment across the Rio San Francisco	1,331,262 00
Narrow-gauge railroad	240,000 00
	$8,036,538 75

Recapitulation. Eastern Division.

The Divide	$11,982,938 00
The Divide to Greytown	8,077,294 00
Twenty miles narrow-gauge railroad @ $16,000	320,000 00
Locks	3,561,515 00
Harbor of Greytown	1,766,625 00
	$25,708,372 00

Grand Recapitulation.

Western Division (Lake Nicaragua to the Pacific, 17.27 miles)	$17,484,048 00
Middle Division (Lake Nicaragua, Rio San Juan, Valley of Rio San Francisco, 133.05 miles)	8,036,538 75
Eastern Division (Valley of the San Francisco to Greytown, 19.48 miles)	25,708,372 00
Total Estimated Cost	$51,228,958 75
Surveys, hospitals, shops, etc., management and contingencies 25 per cent.	12,807,239 00
Grand Total	$64,036,197 75

"The prices adopted are believed to cover the cost of the work under any possible unfavorable conditions, if controlled by intelligent business management."—Report of U. S. Nicaragua Surveying Party, p. 40.

"It is believed that the canal can be completed in six years. The route is believed to be perfectly practicable, free from complicated or doubtful engineering problems, and the most economical, convenient and safe route for inter-oceanic ship-canal communication between the Atlantic and Pacific Oceans, not only through the State of Nicaragua, but across the American continent."—Id.

Due regard in works of great magnitude in tropical countries must be paid to the matter of installation of officers, they should be kept at their work six months of the year, and they should then be required to leave the tropics, and remain in healthful temperate latitudes the remaining six months; only in this way can a vigorous prosecution of the work be assured.

The people of the United States demand the construction of a ship canal along this route, by the Government of the United States, in the interest of all its people for the general welfare, and its strict and entire ownership by the Government. Any proposition looking to the construction of this route by a private corporation subsidized by the Government with $100,000,000, or with any other sum, will be regarded and treated by the American people as unconstitutional and revolutionary on the part of the officers of the Government, as regardless of the bright light shed by the lamp of experience, as destructive of the principles of free water highways, and as an abandonment of the principles of the Declaration of Independence, of the Constitution of the United States, and of the rights and interests of the people of the United States.

They urge the prompt and vigorous, the strict and exclusive, the constitutional and economic action of their Government, because this narrow strip of land, the subject of these remarks, has been permitted too long to embarrass, retard, oppose and obstruct Trade, Commerce, Civilization and Union.

They urge their Government to break down this barrier to commerce, for then the Atlantic Coast of the United States and the Gulf of Mexico become the focus of the world's commerce. They urge their Government to break it down, for then will an enterprising nation experience the force and just expression of those words which a grateful people have inscribed in letters of gold upon the last resting place of one of their greatest statesmen: "There is the East, and there is India."

They urge their Government to break down this barrier to trade and to civilization, and it will re-create America, and a great nation will burst forth in the lofty language of gratulation. Break it down, and an age of distributive opulence will immediately succeed an age of congested wealth. As a nation break down this barrier to commerce, and American commerce covers the seas, and "Civilization on her luminous wings soars Phœnix-like to Jove."

LIST OF AUTHORITIES.

The American Inter-Oceanic Ship Canal, Admiral Daniel Ammen, p. 45, *et seq.*

The Maritime Canal of Suez, p. 151, etc., Nourse.

Problem of Inter-Oceanic Communication by Way of the American Isthmus, by Lieut. Jno. T. Sullivan, U. S. N., containing the reports of the United States Inter-Oceanic Canal Commission;

the invaluable letter and report of Matthew F. Maury, of July 2nd, 1884, to John T. Rockwell, H. R., on the Resources of the Gulf of Mexico and the Carribean Sea, and the Importance of Inter-Oceanic Communication ; the report of Professor H. Mitchell, U. S. Coast Survey, on the Terminal Points of the Proposed Canal by Way of Nicaragua and Darien, and a report by Lieut. Frederick Collins, showing the gain in time by a vessel using the route at Nicaragua as over one using the Panama route.

Reference is also made to the special reports of Commanders Lull, Menocal, Selfridge, and other officers of the Government. To a pamphlet by the writer, "Government Construction and Ownership of the Nicaragua Canal a Necessity." To the *People's Press* of Feb. 18, 1893, Jan. 7, 1893, referring to the concessions by Nicaragua and Costa Rica to a private corporation. To the Frelinghuysen-Zavalla treaty, signed by the Ministers Plenipotentiary of the two governments, the United States and Nicaragua, and improvidently withdrawn from the further consideration of the Senate by the President of the United States.

To the *Rural Press*, of San Francisco, of Dec. 21st, 1892, article entitled The Nicaragua Canal, signed M. N. M., and the *Rural Press* of May 28th, 1892, an article entitled the Nicaragua Imbroglio, and signed M. N. M.

Jeans on Waterways and Water Transports.

Mullhall's Dictionary of Statistics, Title Suez Canal.

The Statesman's Year Book, Title Suez Canal.

Riverside Press, June 28th, 1892, and several numbers following this, containing a series of articles by G. W. Sherwood, C. E., for some time a resident engineer on the Nicaragua route.

San Francisco *Industry*, October, 1892.

DISCUSSION.

MR. HENNY.—"Mr. Manson advocates that the United States take hold of this enterprise. As I understand the position, there is in existence a company which has made surveys and expended some money, and have obtained certain franchises from the United States. I would like to ask Mr. Manson to what extent this company would interfere with our Government taking hold of it."

MR. MANSON.—"As I understand that feature of the question, the Senate of the United States has assumed a certain control over

the corporation. The ouster of the Government and the possession of the corporation under the pretext of Senatorial control is in itself significant. The assumption of control of a corporation in possession of a great water highway is very dangerous on the part of a branch of the General Government. The general effect is instead of the branch of the Government controlling the corporation, the corporation controls the Government. We have witnessed somewhat similar results several times in our history. The general run of people in the United States would look upon it, very correctly, as getting the Government under the control of the corporation. The mere possession of the corporation, under the circumstances, demonstrates its influence and power over the Government. It is a matter of some surprise among a great many people how a private corporation got in there, and got the Government out, when the latter had made the numerous surveys to which I have alluded, in order to determine the most feasible and practicable route for a great national improvement, and after they had made an examination of the whole isthmus, and had decided that the Nicaragua route was the most economical and desirable.

The corporation wants to obtain a large subsidy from the United States, and says it will build the canal with the money thus furnished, and the Government "can control the corporation." I have read the concession to the corporation from the State of Nicaragua, and it prohibits any *real* control by a foreign government. The corporation is operating under an alleged franchise from the United States; it has been shown that the granting of such a franchise is denied to the General Government. If the Government cannot control the franchises in its own country, how can it control a franchise in a foreign country under concessions of this character? It will be impossible. The concessions, considered by themselves, will not permit it. Therefore, any subsidizing by the Government of the corporation in possession of the route under such concessions would be an abandonment by the Government of its right to possess this route, of its purse, of its principles, of its well-settled policy, and of its people.

It seems to me that if the corporation can get the Government to give up to it the natural and geographical right of the people of the United States to the possession of this canal they have accomplished all they want. If the Government subsidizes and recognizes them in such a way as to stand in with them under their concessions, the

Government commits itself, and recognizes their possession as against the right of possession of the Government.

I have followed the reports of the corporation pretty closely. They have had their charter since February 20, 1889, and yet but little work has been done. The men connected with it represent great wealth, and it seems to me that if they proposed to build that canal, and were engaged in a legitimate square undertaking, that they would put their own money in it and build it themselves. If they will do this I will have nothing to say about it. But I regard it as the crucifixion of a nation for the Government to subsidize this corporation for one hundred million dollars, or fifty million, or fifty dollars, because the effect is to yield up the principles and declarations, the right, the interest, and the duty of the Government, repeatedly expressed on that question.

To come back and answer the question more specifically as to the relations between the Government and the corporation. If that route were to be opened tomorrow by a private corporation, and the commerce of the world was subjected to high rates of toll, what would be the result? It is clear that unless that corporation was backed up by a powerful Government it would disappear; the people would not stand it. The corporation realizes this, and it wants a powerful Government to aid it in holding possession at Nicaragua against the interest and right of the people. Capital does not seem to bear in that direction; I don't think banks will put money into that enterprise. The corporation is in possession of a route, but cannot get private capital to build the canal, and it turns to this Government to back it. It might perhaps turn to England, Germany or France for this aid, but those Governments do not want to encounter the Monroe Doctrine, which the select committee of the House has declared to be distinctly involved. Perhaps it might get help from the Brazilian Government, or some other South American governments, but those governments would not be strong enough to cope with that great people, whose commerce is profoundly affected by any enterprise connecting the oceans embracing their country and which connects their greatest sea ports and the mouths of their greatest rivers. So it turns to the United States. The corporation must either carry forward the work on private capital, or get a subsidy from the United States. As I understand the position of our purest statesmen, they demand the construction and ownership of this canal by the Government of the United States for the general welfare, and for the enrichment of no private corpora-

tion at the expense of the industries and commerce of the people of United States. You may say in answer to that, Nicaragua and Costa Rica will be unwilling to furnish any concessions of this kind to a foreign Government. The advantage which that route offers to Nicaragua, as a great national improvement, is as manifold as any other great national improvement is an advantage to our own people. Any great national improvement accomplished by the Government itself always brings prosperity and wealth to the nation. It is truly for the general welfare. No people understand that better than the Nicaraguans themselves, and they are willing and anxious to have the canal built in that way.

I have in my pocket a copy of the treaty between our Government and Nicaragua, which was drawn by Messrs. Zavalla and Frelinghuysen. It is admirably drawn, and is very favorable for Nicaragua and for the United States. That treaty was drawn in the interests of the people. Mr. Frelinghuysen was a diplomat of the highest order. Nicaragua was ably represented by Joaquin Zavalla, Minister Plenipotentiary and Ex-President of Nicaragua. Under the terms of that treaty the Government of the United States had full management of the canal while it was building. After it was constructed, its management, care and direction passed to a board of managers of six persons, three appointed by the United States and three appointed by Nicaragua, the President of the board was to be from the United States. In case of a tie vote the President had the casting vote. You will see at once that any question of traffic could be solved in favor of that country whose commerce was most profoundly affected and which was most deeply interested in the freedom of the Empire of the Sea.

Another favorable feature of that treaty was, that all United States vessels engaged strictly in U. S. coastwise commerce could be favored and passed free of tolls. Mr. Zavalla was equally watchful for the interests of Nicaragua and her vessels engaged in her coastwise trade could be favored and passed free of tolls. Of course due regard to other nations would require that our ships bound to foreign ports pass through at the same rates as foreign ships.

Now, remember that Nicaragua sent its representative to the United States to sign and conclude that treaty, and it was signed and concluded in Washington on the 1st day of December, 1884, by the Ministers Plenipotentiary of the two Republics. Twenty-seven senators were in favor of its ratification and of Government construction and ownership of the canal. But a set of very shrewd,

designing, and ambitious men, probably a commingling of Wall Street and London sharks, saw, or thought they saw, an opportunity to put that canal through in their own private individual interests, and that treaty was very unwisely and improvidently withdrawn from the further consideration of the Senate of the United States. It was a treaty of paramount importance to the people of Nicaragua and of the United States.

By the 6th Section of the Charter of this Government to the corporation it is required to make a sworn report to the Secretary of the Interior on the First Monday of December of each year, giving a detailed statement of its affairs. The last report of the corporation states that a considerable amount of rock was removed at the Machuca Rapids. Some other things were reported, of course, but it seemed rather a strange report. What is meant by a "considerable amount of rock was removed?" Who removed this rock, and how much is a considerable amount of rock, are questions which will help to determine the meaning of that remarkable phrase and infamous practice, "Senatorial control of a corporation" in possession of a great water highway. It looks as if the work was not going ahead as rapidly as it should, and I do not think the corporation will do much there without a Government subsidy. A subsidy must only be given on the terms of strict and entire ownership by the Government of that route. I believe this view is generally approved of by many of our representatives and senators, and that it is the only method of construction of the canal, which will be found in accordance with our institutions and laws, not to mention our interest, our progress, or our civilization.

The Government of the United States is one ordained for the "*general welfare.*" It is not established for the building up of powerful private corporations to accomplish the destruction of the people of the United States. I confess that in this undertaking, and in all others, I wish to see the people of the United States go forward from achievement to achievement, from height to height, and from glory to glory.

DISCUSSION

OF MR. MARSDEN MANSON'S PAPER:

ARE CALIFORNIA HOMES AS HEALTHFUL AS THEY SHOULD BE?

[Read before the Technical Society, and the San Francisco County Medical Society, May 19th, 1893, and published in the Transactions of the Technical Society, June, 1893.]

DR. I. H. STALLARD.—"I congratulate this meeting and the citizens of San Francisco in this attempt to bring the important question of sanitation before the public, and I do so because I believe that until the public takes an interest in this matter, nothing substantial can be done. It is the public who must find the money necessary to make sanitary improvements; it is the public that must be convinced of the necessity of making those improvements. It is not within the power of our Supervisors or anyone else to impose a system of sewerage, or any sanitation, upon a people who are absolutely indifferent to the question. Therefore, we need to ventilate this subject, and I think a debt of gratitude is due to the gentlemen who have taken an active part in bringing about this meeting, and to Mr. Manson for the introduction which he has given us to-night.

San Francisco, at the present moment, is in a kind of transition state, and important questions are likely to be submitted before long to the public. Mr. Manson has drawn particular attention to the foul condition of those districts which have been raised by large quantities of filth and garbage deposits, particularly in the southern portions of the City, and in various parts of the northern portion. I have had considerable experience in these matters. In Liverpool, England, large areas were formerly raised in the same way, but the authorities discovering the unwisdom of this process, have forbidden it by law. This was some twenty years ago. But there is a pollution of the soil in the City of San Francisco, to which I think your attention might very properly be directed. You are aware that we have a vast system of sewers, and that these sewers may be divided into those which come down the hillsides and those which lie in the level portions, that is, south of Market Street, and, we will say, east of Kearny. In a series of heavy rainstorms, more or less detritus is washed into the sewers, and where the descent is rapid it rushes to the bottom of the hill, where the current is slower, and generally, the sewers are larger; the consequence is that the detritus that has been

washed from the upper levels settles in this lower part. In this way vast accumulations have taken place.

In the year 1886, I think it was, a large sewer was built on Channel Street. That sewer had accumulated last year, between five and six feet of deposit; it was nearly filled up with sand and silt. Vast sums have been spent on this sewer to keep it clear. For the last few months one hundred men have been employed in removing the detritus from this one sewer and the small branches which are tributary to it. The expense for this year has already reached $19,000. A thousand tons of gravel and a thousand tons of filth and silt have been taken out, and as much more remains. It was found last year that after a night's rain it raised the deposit two inches, and it would take an entire day to remove what had been deposited in one night. The debris accumulates first of all in the side sewers, and it takes a staff of men two weeks to clean a sewer two feet by five in one block. You can imagine what a labor you have in hand here, and the enormous expense.

The result of these accumulations is that the sewage, which comes down from above, not having a free and good escape, the gas from the sewer is injected in all directions into the subsoil under the houses. Experiments in Munich have shown that the air of the subsoil is capable of being conveyed a very considerable distance under ground. Therefore, where the surface of the street is sealed by bitumen or granite pavement, these gases escape in the basement of buildings, and find their way in various ways to the interior of the house, and are taken into the system by the occupants. Good plumbing is of great importance, but it does not meet this difficulty —in fact, the passageway for the pipes furnish a means for these poisonous gases to circulate. I have repeatedly found an odor of sewer gas in typhoid fever cases.

The question we have to meet is, how to convey the sewage away without a possibility of its being injected into the subsoil. Two things are necessary: First, the sewer must be so impervious that there is no chance of the sewage getting loose. No big brick sewer that you can make is impervious. The moment it becomes filled, it injects foul matter right and left through the soft brickwork. During the summer months there is nothing in the sewers except what is pumped in by the Spring Valley Water Co., and those sewers which are in the lower and flat portions of the City have such a sluggish current that sewage accumulates at the bottom, and the production of sewer gas is carried on to an enormous extent, and the consequence is that there is a pollution going on all during the summer

time, which is even worse than it is in winter.

In the second place, the sewers must be so constructed, that they can readily be kept clear, and thus avoid any great accumulation of matter and the stopping of the sewage.

Now, I think this is a most important question. I have limited my observations to this because it is a part of the subject that Mr. Manson has treated. He has spoken of the foul condition of the subsoil upon which many of our houses are and will be built, and I agree with every word he has said upon that subject. But I hold that the contamination of the subsoil from the sewers is vastly greater than that which comes from the deposit of garbage, because that, after all, is a local affair, but this other is general throughout all parts of the City where the sewers are nearly all approximately level.

I am glad that this step has been taken, and I hope this will not be the last meeting of this kind. We ought to have a general sanitary association of the citizens of San Francisco to promote the teaching of sanitation among the people, and to show them the frightful amount of disease and death which comes from neglect in this particular. In a lecture delivered in this City last year, I endeavored to show that at least four thousand deaths a year are unnecessary, because of bad sanitary conditions. I proved that by a comparison with other cities, and also by a reference to the nature of the diseases from which our citizens died."

E. J. MOLERA.—"I think it would be well to have some members from both the Medical and Technical Societies appointed to outline a plan for improving the sanitary conditions of San Francisco, not only as to sewerage, but also as to the building of houses so that they will become healthful. The sources of water supply should be considered likewise. Mr. Manson has pointed out the dangers of pollution from the water supply. Let that be thoroughly considered. I think if this matter were presented to the public, there would be no trouble in passing laws necessary for the improvement of the health of our City."

DR. BUCKLEY.—"I came here this evening intending to be a silent listener. I do not know that I have anything to urge in addition to what has already been said. I think one great trouble with our sewers is their defective construction to begin with.

I will mention an instance or two in my practice indicating the necessity of a pure water supply. It is a very well known fact that impure water is a great source of disease. Some years ago I was

called to attend a number of boys who were sick at Old St. Mary's College. They were all down with a fever; it was not very pronounced at first, but I considered it typhoid. I attempted to find out the source from which they were contaminated, and had an examination made of the water tank through which the water supply of the college passed. The tank stood on a platform by itself and was about fifty feet above ground. On investigation a dead rat was found in this tank, which caused all the poisoning of these boys. Fortunately none of them died, but about seventy-five suffered from fever, and before they recovered were in a very dangerous condition.

At a later period I was called down to San Mateo County to a farmhouse, and there I saw the lowest and worst form of fever I ever witnessed in my life. Three grown children had been buried in the garden within a week, and the farmer's wife and three more children were nearly at death's door. I investigated the source of water supply, and found that that idiotic man had a sink from his stable absolutely draining into his well, from which they drew their drinking water. This simply emphasizes the necessity of pure water, a fact which Mr. Manson has so ably dwelt upon already."

DR. MCNUTT.—"Mr. Manson has urged the necessity for a pure water supply. It is pretty well understood now that a large number of diseases are carried in the water, such as typhoid fever, cholera and many others. I suppose that our sewer system is about as bad as it can be. I do not propose to go into a description of a complete sewer system, because there is a great deal of difference of opinion about sewers. Some think we should have sewers for carrying off waste water only, and separate sewers for carrying the debris. That, of course, is a matter for engineers to solve. I know that at some future time we will have the matter regulated.

There is a great deal more to deal with in the sanitation of dwellings than the mere sewerage and the water supply. Dr. Stallard has pointed out how foul gases permeate the houses. Oftentimes sewer pipes, made of porous cement, are run under the house, which allows the gas to escape into the cellar and basement, and contaminate the entire building; and this without any breaking of the sewers whatever.

The washstands in many houses seem to be about as badly regulated as possible, and the tanks do not receive much attention. Then again the system of bathrooms and water closets in the middle of the house is a mistake; these could be placed outside, or to one side of the house, where much less injury would be done from gas that may escape through them. Washstands and water closets

should be placed where they can be well ventilated.

Dr. Stallard strikes the keynote when he says you must educate the people to realize the importance of these matters; they do not seem to realize the great importance of good sewers, pure water, or a system of ventilation for their houses. I think it would be well to teach the growing children in our public schools this subject; and when they grow up and become our Board of Supervisors, and our people in authority, they will probably make some progress in this direction. But until then, it seems rather up hill work to get the citizens to take hold of sanitary improvements as they should."

Dr. Stallard.—"I would suggest that a Committee be formed from the two Societies, and that this Committee inaugurate meetings of this kind, and take up these questions in a regular order, limiting the discussion to certain particular points. The subjects might be, for instance, something like this: The relation of the sewer gases, or the water supply, to the propagation of any disease; what the ultimate disposal of the sewerage of the City shall be; what shall the sewers convey; what limitations shall be put upon the use of the sewers, etc. I think this would do considerable towards enlightening the public on these matters.

I wish to make another remark upon the question of malaria and water. One of the most remarkable examples of the effects of water used from deep wells has been shown on the large ranches of Mr. Haggin, in the neighborhood of Bakersfield, Kern County. In former times that locality had the most malignant forms of malaria; scarcely a person who was not seized with it in the most serious manner, and it was quite dangerous to life. Mr. Haggin has, I think, eighteen ranches there, and on every one artesian wells have been sunk; since the use of that artesian water the malaria has almost disappeared. It has become so mild that there is really no serious consequences to the inhabitants. I think that is as strong a confirmation as anything can be of the correctness of Mr. Manson's conclusions on this subject."

Mr. Manson.—"Since this paper was read and discussed, the City of Oakland has been subjected to a remarkable outbreak of typhoid fever. So far as can be ascertained the disease was originated by the use of contaminated milk from a dairy using filthy water for watering the milch cows, washing cans, and probably for diluting the milk. The disease was also aggravated and extended by foul and defective sewers, thus furnishing a sad and costly object lesson near at home, and in a city which should be nearly—if not absolutely—free of filth diseases."

REGULAR MEETING, JULY 7th, 1893.

PROCEEDINGS.

MINUTES.

The meeting was called to order at 8:30 P. M. by the President, C. E. Grunsky.

The minutes of the last regular meeting were read and approved.

Elections to membership. After a ballot the following were declared duly elected :

For Members :

Richard Gernon, County Surveyor.....Tehama Co., Cal.
Frank P. Medina, Electrical Engineer.....San Francisco, Cal.

Junior Member :

Wm. W. Fogg, Civil Engineer.....Oakland, Cal.

Associate :

Otto Putzker..... Berkeley, Cal.

The following propositions were read, and referred to the Executive Committee :

For Members :

Julius H. Striedinger, Civil Engineer, San Francisco, Cal.; proposed by H. C. Behr, Marsden Manson and Otto von Geldern.

A. Patton, County Surveyor, Tulare County, Cal.; proposed by E. Newman, H. H. Davenport and P. M. Norboe.

The report of the committee appointed to consider the proposition of merging the Electrical Society with the Technical Society was called for, and Mr. Henny, as one of the committee, stated that certain measures were to be proposed, but as the chairman of the committee, Mr. Dickie, was absent, and but few of the members of the Technical Society present, he proposed to lay the matter over for another month, and therefore asked for further time, which was granted.

Mr. N. J. Manson read a paper entitled : " Inter-Oceanic Ship-Canal Communication by the American Isthmus. Its Geographic and Economic Relation toward the United States," dwelling par-

ticularly upon the proposed Nicaragua route. The economic aspect of this subject was subsequently discussed.

Upon request of W. A. Doble his paper for the evening, regarding the "Use of Coal Oil in Steam Boilers," was laid over for reading and discussion until the next regular meeting.

Mr. Bestor spoke of the proposed California Midwinter Fair, and suggested that the Technical Society take some action to show its willingness to aid the undertaking that was now under general consideration by the people. After some discussion it was moved by Mr. Bestor that four members be appointed, who, together with the President, shall constitute a Midwinter-Fair Committee, to confer with the Executive Committee of the proposed exposition, and determine in what manner the Technical Society could aid the enterprise. The motion was seconded and carried, and the President subsequently appointed the following members: Horace B. Gale, N. S. Keith, Hermann Barth and Otto von Geldern.

The sad news of the death of one of the prominent members, P. J. Flynn, Civil Engineer, of Los Angeles, was communicated to the Technical Society. Steps will be taken in the immediate future to a proper recognition of this sad event.

Adjourned. OTTO VON GELDERN, *Secretary.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

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NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

NOTES ON ARTESIAN WATER

AND THE

EFFECT OF IRRIGATION ON SUBSURFACE WATER IN THE SAN JOAQUIN VALLEY.

By C. E. GRUNSKY, Mem. Tech. Soc.

[Read August 4th, 1893.]

The water which percolates through porous soils, or which flows into crevices of the geological formation at the surface of the earth, and enters by infiltration into the pervious strata of which the earth's crust is in part composed, not infrequently finds lodgment in localities where it becomes an important source of water supply.

It is such waters permeating to subterranean layers or gravel or sand, which are confined between impervious geological formations, that rise to the surface in the many artesian wells that have been bored in this State.

The term artesian has been derived from the Province Artois (Artesium), in France, where the practice of boring for water found favor in the beginning of this century.

NOTE.—Portions of this paper, particularly those relating to loss of water from canals, and to the effect of irrigation on soil-water movements, are from experiments made and notes prepared by the writer as Assistant State Engineer, 1882 to 1887. Some others are from a paper read before the State Grange, at Sacramento, in 1889.

Boring was practiced in a very early day in China, in many parts of Europe, in Asia Minor, and in Egypt, and spontaneously flowing wells were by no means unknown in the countries named, though but little attention has, until within this century, been devoted to a systematic development of artesian waters.

The term "artesian" should never be applied to any water which does not spontaneously flow above the natural surface of the ground. Although authorized by some compilers of dictionaries, it is always misleading to apply the term to wells from which no water can be obtained unless raised by pumping.

The water in such geological formations as are water bearing, has all had to travel a greater or less distance through the air in the form of rain or snow, thence perhaps across portions of the earth's surface, and finally through subterranean channels and interstices, between particles of minerals, earth and rock, to the particular point at which it has found lodgment. In this course it has been charged with gaseous matter, ammonia, carbonic acid, and with a certain amount of organic as well as inorganic matter. According to the route traveled, the subterranean water, originally pure, is always within wide limits charged with foreign matter. Its quality for domestic use, irrigation, or medicinal purposes, depends upon the character and quantity of the ingredients thus entering into its solution.

The water from a well on the northeastern shore of Lake Tulare, from the depth of 23 feet, is saltier than ocean water. The artesian waters from the Tulare County wells nearly all hold in solution, together with other substances, small amounts of sulphuretted hydrogen. Those of Merced County, nearest to the San Joaquin River, are so strongly mineral in character that important medicinal properties are claimed for some of them. The deep wells near Stockton bring water to the surface from which large quantities of inflammable gas are liberated.

Only experience, then, can be relied upon to determine the quality of water that can be drawn from sub-surface, water-bearing strata.

Artesian water is rarely struck in fissures of rock, so rarely indeed that it is absurd to bore for artesian water in localities where it is known that the geological formation does not present stratification of large extent.

Where stratification does exist, particularly if the layers be nearly horizontal, it will be found that not infrequently a stratum of

pervious material, of which sand and gravel are typical, is enclosed between two strata, the one above, the other below, of impervious material such as close-grained rock or clay. If such a layer of gravel extend at any point to the surface of the earth it may there receive a supply of water which, according to the amount of supply and relative elevations of the different points of the stratum, will permeate a portion of or perhaps the entire gravel bed.

If the gravel bed dip away from the point of inflow of water, and has no outlet, it is evident that as the water accumulates in the stratum to saturation the pressure under which it is confined will rise until the head of water for all points of the gravel bed is equivalent to the height of the point of inflow.

Should it now happen that some part of the surface of the earth directly over the gravel bed have an elevation less than that of the height of the point of inflow, then a boring from above to the gravel must secure artesian water, unless the same be lost by leakage through a defective casing.

The layer of sand or gravel confined between an impervious water-bed below, and an impervious water-cap above, is typical of all artesian belts in this State of which the writer has any knowledge. It is important to bear this fact in mind at all times in discussing the question of source of supply of any well or group of wells.

Deep as borings have hitherto been made, the same experience has everywhere been had, down to bedrock of our large valleys, of our mesas, and of our deserts, layers of pervious material alternate with impervious material, and the well-borer knows that if his boring were continued through the gravel bed, in which perchance he has stopped, he would find beneath this pervious material an impervious stratum.

It is very easy then to trace our artesian waters to their source. The water must come from a distance, it must sink somewhere beyond the edges of the water-cap. It cannot come from underneath, access from below being cut off by the impervious water-bed. It must therefore enter the gravel or sand stratum, as the case may be, at the point where the same crops out at the surface, or at least connects with pervious material at the surface.

It is folly to look for a source of the artesian water of San Joaquin Valley in the Sierra Nevada. None of our beautiful mountain lakes will ever be run dry by tapping the water-bearing strata of our great central valley.

Our great valley was at one time a great inland sea. Mighty

glaciers were at work grinding down mountain chains, and depositing vast terminal morains along the base of the mountain slopes.

The waters of the inland sea deposited layers of clay, of which some are in places more than 100 feet thick. Sand was swept over them, gravel was run over them at some points, and the surface of the valley rose as the mountains were worn down by the ice and water. The clay layers are thickest where the water of the sea was deepest — near the central line of the valley — they taper toward the east and west.

It is needless to discuss what convulsions of nature caused periodical interruptions of the deposit of clay and the formation of the sand strata. It is enough to know that the many borings that have been made prove the continuity of the clay layers, and demonstrate that, to unknown depth, clay alternates with sand and gravel.

The pervious strata, open as they are to a source of supply, at once become Nature's subterranean water conduits, flat and wide. For long distances they are closed conduits. The water they receive permeates all portions of them lying lower than the source of supply, whenever it enters in sufficient supply.

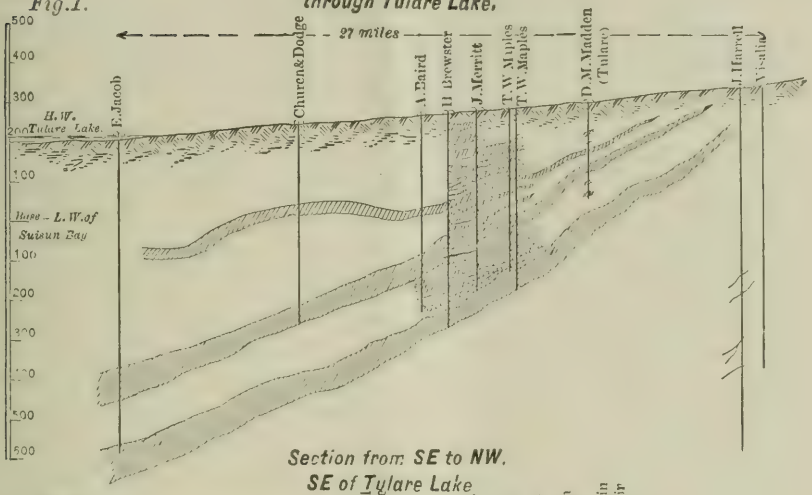
San Joaquin Valley is 250 miles long, and about 50 miles wide. The mountain ranges between which it lies are nearly parallel. The western slope of the Sierra Nevada Mountains, toward the valley, is 50 to 80 miles long. The eastern slope of the Coast Range is generally but 5 to 10 miles in length. More detritus has been swept into the valley from the long slope of the Sierra Nevada than from the short slope of the Coast Range, consequently the present trough of the valley lies much nearer to the base of the Coast Range than to that of the Sierra Nevada.

The valley, where it opens out toward the outlet through the Coast Range, has not yet been built up to the height of high tide in the ocean. Nearly 500 square miles of its surface at this point are almost absolutely level, thence land rises very gradually in the direction up the valley, but more rapidly toward the base of the mountains from points at the edges of the valley's trough. The lands rise faster toward the Coast Range than toward the Sierra Nevada.

In round numbers the general elevation of valley lands at the head of the valley is 400 feet above the sea, it is 200 feet near Tulare Lake, it is 400 feet at the base of the Sierra Nevada directly opposite this lake. It is the same at the base of the Coast Range northwest of the lake, it is about 300 feet at Fresno, 150 feet in the

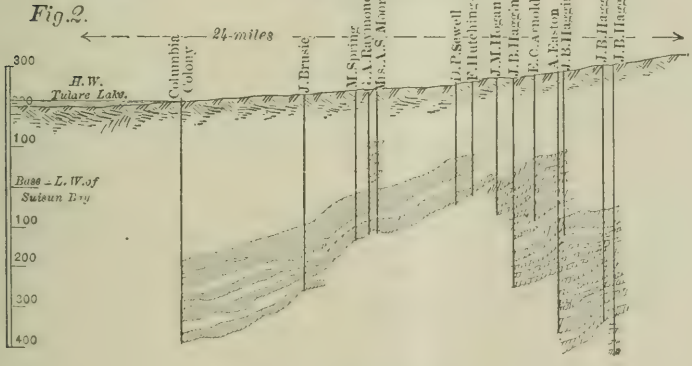
Section from NE to SW,
through Tulare Lake.

Fig.1.



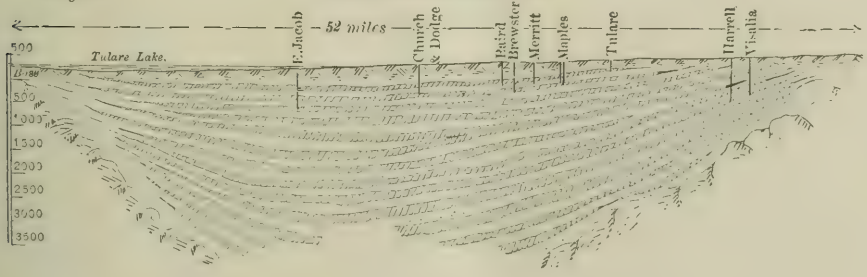
Section from SE to NW.
SE of Tulare Lake.

Fig.2.



Ideal Cross Section of San Joaquin Valley
through Tulare Lake.
showing Stratification.

Fig.3



Base Low Tide of Pacific Ocean

trough of the valley directly west of Fresno, 170 feet at Merced, 20 feet at Stockton, 110 feet at the base of the hills east of Stockton.

The great eastern plain in the San Joaquin Valley has a surface slope of from five to ten feet per mile from the mountains toward the valley trough.

From the records of a great many deep borings it becomes apparent that to the full depth of the deepest boring in the San Joaquin Valley (about 3,000 feet at Stockton) pervious and practically impervious formations, of which clays and sands are typical, alternate in layers of varying thickness; that these layers have greatest thickness near the trough of the valley, decreasing toward the hills upon either side of the great valley; that their pitch from the hills toward the trough of the valley is greater than that of the surface, and increases with the depth, and that these layers lose their distinctive characteristics near the edges of the valley where, approaching the surface, they become merged in the surface formations.

The cobble, gravel and sand beds of recent formation at the outfall points of the many rivers and creeks upon the valley plains receive the sinking waters of these streams, and become the bountiful source whence the pervious strata of all depths draw their supply of water.

They may, when tapped from above, yield indifferent or excellent supplies of water according to the extent of each water-bearing stratum, the character of the material of which it is composed, the existence or non-existence of a natural point of outflow, and many other causes. The greater the depth from which the water rises the better is the prospect of obtaining an ample supply, because other conditions being the same, it is reasonable to presume that there is less likelihood that a natural outlet from a deep water-bearing formation should exist than in the case of others at a less depth.

Borings in the San Joaquin Valley, to the number of about 300, bear out these conclusions, and a careful study of the well-borer's records reveals the further fact that there are points where some cause has interfered with the continuity of the great clay deposits. These points lie near the present river channels, and it is very likely that a large flow of water down the present river canyons into the sea was accompanied by a sand flow deposited in long ridges out from the present base of the hills toward the west.

The Tule River outflow in Tulare Lake marks one of the points

where the deposit of clay has been interfered with. Kings River delta is another.

It must be apparent that when the source of supply can be so readily defined as in the case of the wells of the San Joaquin Valley that a conjecture is permissible as to the aggregate possible yield of all the wells in clearly defined districts. The writer's prediction in this respect in reference to the decrease of flow, or complete failure, of many of the wells in the San Joaquin Valley have fully borne out this view.

The combined flow of one hundred wells in Tulare County, examined by the writer in 1884, was 33 feet per second (20,384,000 gallons per 24 hours). Of these twenty had been examined two years before. Two of these re-examined wells had ceased to flow, both being located near the eastern or upper edge of the artesian well belt of the San Joaquin Valley. One of these had been sunk in 1878, and maintained a good flow until 1882, after which time, while the number of wells in the vicinity was being increased from 20 to 100, it gradually failed and ceased to flow entirely in the summer of 1884. The other was sunk in 1882, and its flow was then about 18,000 gallons per 24 hours.

The flow of twelve others of these twenty wells had decreased 56 per cent. in the two years, but the decrease had been so gradual that but few of the well owners would admit that a material change had occurred.

It cannot be hoped to establish the interdependence of wells in artesian belts of such great extent as those of San Joaquin Valley by means of experiments made in capping or uncapping wells. The great time required in producing an effect must needs make it impossible to establish with certainty a connection between cause and effect.

The effect is necessarily small, even when two wells are close together and are known to draw water from the same source. It is precisely the same as when two relatively small hydrants are connected by means of two separate pipes with a common large water main. The closing of one produces no perceptible effect on the other, because the hydrostatic pressure in the main is barely affected by opening or closing so small a vent. Yet, as every one knows, the many taps and hydrants distributed throughout a city provide escapeways for the entire water supply in the city main, and all combined are limited in their discharge to the amount which, from some source, is supplied to the water main.

Whenever the flow of an artesian well is checked, the hydrostatic pressure in the stratum from which it draws water is raised, and the longer the well remains closed the nearer will the same approach to that pressure which existed before the well was sunk. To this fact is due the phenomenon of the increased flow whenever a well is uncapped. In some cases such increased flow continues for hours, in others for days or weeks, and there is no doubt that after first being opened an artesian well in the central or lower part of San Joaquin Valley must flow for months before it settles to a constant or normal flow.

The long period required for such adjustment, which seems in conflict with hydrostatic laws governing the flow of water in closed conduits, is due to the influence of the friction to which water is subjected in its flow through pervious formations toward the point of discharge.

Having in the foregoing presented a condensed illustration of water movement in pervious strata sandwiched in between two impervious layers, the water bed and the water cap, the question: What becomes of the water which by infiltration through surface layers reaches the uppermost impervious layer by which its downward movement is interrupted? remains to be answered.

The intercepting layer may be but a few feet below the surface where a layer of genuine hardpan or bed rock lies under shallow soils and subsoils, or it may be at a great depth where porous sands and loams extend hundreds of feet beneath the surface. In either case the water intercepted by this impervious layer seeks its level. It flows, but its flow is retarded by the obstructions in its path.

The water in surface formations, above the uppermost impervious layer of clay or other material, is commonly designated surface or soil water, and is, as a rule, always found where rainfall is sufficient to wet the soil to a depth beyond the reach of capillary forces that bring the moisture to the surface where it is rapidly evaporated. Surface or soil water is augmented by seepage from natural or artificial water courses.

The rivers reaching the San Joaquin Valley from the slopes of the Sierra Nevada, are of two distinctive general types, those which, like the Calaveras and the Kern Rivers, debouche with their water surface at, or very nearly at, the general level of the valley lands, and those which hold their courses in secondary valleys, cut deep below the surface of the main valley, far out from the base of the mountains.

The Mokelumne, Tuolumne, Merced, San Joaquin and Kings Rivers belong to this second class.

To fully discuss the movement of underflow, and particularly of the increment due to infiltration from these rivers, and from the canals supplied by them, would carry this paper beyond intended limits, but some notes particularly of the region watered by Kings River will be given.

Kings River discharges into San Joaquin Valley the drainage from 1742 square miles of foothill and mountain lands. By far the greater part of its watershed lies in the high mountains of the Sierra Nevada, where nature stores the snows of winter to augment the flow of the river during the warm months of spring and summer. Kings River is generally at a low stage during the months of September to January inclusive, it is at a medium stage during the months of April to July inclusive.

The least average mean monthly discharge of the river for any month during the six years from Nov. 1st, 1878, to Nov. 1st, 1884, has been noted for November, it is 313 cubic feet per second. The least flow of the river noted for any single month of these six years was 220 cubic feet per second. The extreme low water flow of the river has probably never dropped below 200 cubic feet per second. At its medium stages this river carries 1,000 to 2,000 cubic feet per second, while during the high stages the monthly mean for the six years above named averaged from 4,000 to 8,200 cubic feet per second. The greatest momentary discharge of the river during this period occurred in June, 1884, at which time the discharge reached 30,000 cubic feet per second. (See P. D., State Eng. Dept., Cal., pp. 542 and 476.)

Kings River enters San Joaquin Valley at a point about 20 miles east of Fresno. It has a broad channel, between hills which rise very abruptly upon either side before it enters the Centerville bottoms. Through the bottom lands the river courses in a number of small channels, over and between cobble gravel and sand bars until at the "Narrows" it is again confined to one channel lying between bluffs about 60 feet high upon either side. Its length through Centerville Bottoms is about 14.5 miles, and its grade per mile 8.23 feet. At the upper end of Centerville bottoms the elevation of the plain is only about 10 feet above the river. At the lower end it is, as has just been stated, about 60 feet. Below these bottom lands the elevation of the river banks gradually decreases. About a mile below Kingsburgh the river water at medium and high stages divides, some

Kings River Country.

going westerly through Cole Slough to Fresno Swamp, thence to San Joaquin River, while the rest flows southwesterly into Tulare Lake.

At points where the plain is but little elevated above the surface of the river is the natural location for canal headworks. These are therefore found along Kings River in two groups. The upper one at the upper end of the Centerville Bottoms, the other below the crossing of the Central Pacific Railroad.

The lands of the plain generally slope away from the river, consequently there is little or no drainage from the plains into Kings River. Its only tributary from the hills, entering below the point where it reaches San Joaquin Valley, is Wahtoke Creek, which discharges into Kings River from the east at the Narrows.

The canals which supply Fresno and its surroundings with water are the Kings River and Fresno canal, the Fresno canal, the Fowler-Switch canal, and the Centerville and Kingsburg canal. These all take water from the north side of Kings River, about 18 to 20 miles east of Fresno.

The natural water courses of the Fresno plains are small creeks of torrential flow in the winter and no flow in the summer, whose waters are lost in sinks. These have in large part been utilized as the waterways for the canals, and the canals thus become the recipients of the drainage water from the plains and foothills.

The general slope of the valley lands near Fresno is from northeast toward the southwest at the average rate of about six feet per mile.

Near Centerville the soil of the plains near the bluff is a red sandy loam resting on a yellow clay, which is usually at a depth of four to six feet below the surface. The soil is sufficiently heavy to bake somewhat on the surface in drying out after being wet. Hard pan, as the clay is called, is not continuous ; it disappears frequently at about one half mile from the edge of the bluff, where the surface soil becomes lighter, more sandy. At depths of ten feet or more beds of cobble and gravel are here found which, in close proximity to the low river bottoms, afford thorough underdrainage to these lands. The soil is very productive. Ground water is at twelve to fifteen feet below the surface.

Westward from Centerville toward Fresno the soil is a loamy sand. This generally rests on irregular patches of firm clay hardpan, sometimes impregnated with sand. Soil is one to three feet deep. These plains in their original condition were treeless.

At the sinks of the creeks, which are generally a few miles to the eastward of Fresno, soil is a heavy red loam, bakes on the surface after being wet, where a hard-pan substratum is encountered at all it is at 10 to 30 feet below the surface. Westward from this region the soil is a heavy loamy sand several feet deep, resting on a firm clay called hard pan. This soil toward the southwest merges into the sandy soils of the alkali belt which skirts the edge of Fresno Swamp, and this in turn is succeeded by the rich peaty alluvion of the swamp lands. To the south of Fresno the sandy soils of Fresno and Central California colonies change to the light so called ash of Washington colony. Here the hard-pan dips further below the surface, and there are points where it has disappeared altogether. In the southern and southeastern portion of this district sand predominates. The surface of the country is comparatively smooth though crossed occasionally by a low sand ridge. Firm hard pan partaking of the nature of cemented sand immediately below the surface soil is an exception, yet is found in various localities, most frequently where the surface presents the peculiar hogwallow appearance.

All the clays and hard-pans of the region north of Kings River lack continuity, they have been honeycombed by burrowing animals, and are impervious only in relatively small tracts. The pervious character of surface soil is therefore to be considered uninterrupted on the Fresno plains to an uncertain depth of fifty to several hundred feet.

There is probably no other irrigated region in California where the effect of irrigation on the elevation of the water table, or on the amount of soil water, is so plainly apparent as in the immediate vicinity of Fresno.

Here, notwithstanding the six feet per mile slope of the surface of the country, the subsoils have gradually but surely been saturated with water. When irrigation commenced, the loss of water from canals in transit to lands to be irrigated was very great, and after reaching its destination it was found that frequently enough water was put on to the surface of certain tracts of land to have covered them to an average depth of 15 to 20 feet in a season.

The amount evaporating from the surface could not have exceeded five or six feet in the same time, consequently a vast amount of the water diverted from the river for irrigation must have found its way into the subsoils, and was certain to influence the elevation of the ground water. When the first wells were dug at Centerville water was found at about 20 feet, it is now at 10 to 15

feet below the surface, and will probably not rise much higher on account of ample drainage of subsoils and the proximity of the low river bottoms.

Along Fancher Creek, where the creek is used as a canal, ground water was formerly at 50 to 75 feet below the surface. It is now at 12 to 20 feet along the upper portion of the creek, and still nearer the surface near the former sink of the creek.

In the Eisen vineyard, five miles east of Fresno, ground water is at four to six feet below the surface, and drain ditches have been constructed to prevent a further rise. Ground water is only four feet below the surface in many parts of Temperance Colony, Nevada Colony, Fresno and Central California Colonies. Throughout a considerable area near Fresno it nowhere exceeds 16 feet below the surface.

Cellars which were in use until 1884 in Fresno have been condemned, because the ground water made its appearance in them. Yet in Fresno, and many miles to the west and south, no water could be reached at a less depth than 60 feet before irrigation commenced.

Near Selma and Kingsburg ground water was formerly found at about 30 feet. It is now at about 15 feet. The so called "Sand Hollow," which is a depression 100 yards to one fourth of a mile wide, 12 miles long, and about 15 feet deep, having a southerly course, and crossing the Southern Pacific R. R. about midway between Selma and Kingsburg, was formerly as dry as the surrounding plain. About 1880 the soil in its bed was found to require less moisture to produce crops than the adjacent plain. In 1885 water appeared at the lowest points of the bed, and in June of that year had risen to the heads of ripening grain. Spots of black alkali now mar its bed and sides, which before were a light sand apparently free from any excess of alkaline salts.

Near Sanders, and at points eastward toward Kings River, ground water was at 50 to 60 feet before irrigation commenced. It is now at 20 to 30 feet. Here, as in the case of Centerville, proximity to the river, which lies 60 feet below the surface of the plain, may interfere with a much greater rise of the ground water plane.

In connection with this change in the elevation of the ground water plane it must be remembered that it necessarily extends far beyond the points now under cultivation, and that owing to the slope of its surface, ground water has a slow but certain motion westward through pervious subsoils, and will ultimately contribute more

or less toward the flow of Fresno Slough and San Joaquin River.

The rainfall in the Fresno district is greatest near the base of the foothills. It decreases from there toward the west. At Centerville the average fall of rain is about 16 inches, while at Fresno and Kingsburg it is 9 inches. The average fall at Firebaugh in the trough of the valley is about two thirds of that at Fresno. For the irrigated region near Fresno the mean annual fall of rain may therefore be noted at about 11 inches. When this amount of rain falls at the proper time it is sufficient to insure good crops of grain. Throughout a large part of the district this rainfall is relied upon to produce a crop, and irrigation of grain is as a rule resorted to only when a drouth threatens the destruction of a growing crop.

The branches of the canal which supply this region with water ramify through a region covering about 300,000 acres, with plenty of room for extension to the north and west.

Two of the canals irrigating lands near Fresno have a perennial flow, the others divert water only during medium and high stages of the river, generally from January to August inclusive.

The aggregate capacity of the four canals already enumerated is about 1,550 feet per second. None of them flow for long periods at their maximum capacity. The demand for water is fortunately greatest at the time when the flow of the river is greatest during spring and the early part of summer.

Each of these canals was constructed for the purpose of supplying water to some particular locality. Thus Fresno canal to irrigate lands in the immediate vicinity of Fresno; the Kings River and Fresno canal to irrigate a strip of land just north of Fresno canal; Centerville and Kingsburg canal to irrigate lands near Selma, and Kingsburg and Fowler Switch canal to supply water to the vicinity of Fowler and lands westward from that point. By reason of such requirement in each case, each canal received an alignment as direct as possible from the proposed source of water to the point of delivery. The main canals were therefore constructed without any attempt to hold them to any uniform grade. They have alignments in the direction of the greatest fall of the country, and generally when their grade is excessive checkwiers are used to prevent erosion. The flow and elevation of water in the Kings River and Fresno canal, and in the Centerville and Kingsburg canal, is thus regulated. The control of flow and elevation of water in the case of Fresno canal and the Fowler Switch canal is only partial.

Fresno canal, throughout a large portion of its course, occupies

the deep channel of Fancher Creek. Its water flows 8 to 15 feet below the surface of the ground. Very few structures are in use to raise it to the surface, and but little of its water is diverted from this part of its course. The first important diversion from the Fancher Creek portion of the canal is at the Limbaugh dam where the Mill Branch is diverted from the main canal; the second is at the Hobler dam where water is diverted for the Eisen ditch and for the Briggs branch. Below this point the channel of the creek has less depth, and soon reaches its sink whence the canal water flows in artificial channels whose grade is regulated by the same structures which enable diversion of water into the distributaries.

Fowler Switch canal was constructed on a very irregular grade line. Its grade, when possible, was placed at 1.92 feet per mile, which was established as a minimum gradient. At some points, however, the grade was no less than 12 feet per mile for short distances. The dimensions of the canal were calculated on a basis of a fall of 1.92 feet per mile, consequently its dimensions where this grade was exceeded are excessive.

The canal was constructed without structures for the regulation of its flow, or to facilitate diversion. Rapid erosion at once commenced where the canal bed was not in very firm material, and after a short experience a limited number of checkwiers were put into it at the points where most required.

The structures in this and in the other canals of the district are very light but generally well adapted for the purpose which they are to serve. In view of the fact that the irrigation of this district has in the past caused a rise of the ground water plane, and that it will continue to influence its elevation, the question whether, in the end, water is lost by the apparent duplication of canals remains an open one. Certain it is that were all water drawn from the river in one main canal it would still be necessary for branch canals to reticulate through every portion of the irrigated region, the ground water would be expected to rise equally as rapidly as at present, and the only saving of water would result from the exposure of a slightly decreased surface area of flowing water to evaporation, and from a possible reduction of the flow of water from the main canal through subsoils back into Centerville Bottoms. This last saving may be admitted as possible, though it is equally probable that the increased depth which one main canal would have would augment the loss.

To illustrate how insignificant the loss of water from a canal by reason of evaporation is, the average surface width of Fresno canal

throughout its 24.5 miles of length (main canal only) may be noted at 60 feet, and the rate of evaporation may be taken at the maximum average rate per month recorded for any month in the records of the experiments at Kingsburg.* The greatest total evaporation in any month of the four years, November 1st, 1881, to November 1st, 1885, occurred in August, 1883. It was equivalent to a layer of water .945 feet in thickness. At this rate per month the loss by evaporation from the surface of Fresno canal would have been equivalent to a continuous flow of 2.8 cubic feet per second, an amount very small when compared with the amount sinking into the subsoil, or with that remaining available for distribution.

To determine the amount of water which sinks into the subsoil from the canals in the district under discussion, experiments were made in 1882 along Kings River and Fresno, Fresno and Centerville, and Kingsburg canals.

The first of these canals cuts immediately into the high land north of the Centerville Bottoms. For a long distance it is nearly parallel, and sometimes very close to the Fresno canal. Its water surface is at a higher elevation than that of Fresno canal. At many points the canal carries its water above the surface of the adjacent plain. Ponds and swamps are maintained with the water which the canal loses by percolation.

The canal, throughout the last few miles of its first twelve, lies in a good channel with hard-pan bed. Throughout this upper portion the canal in 1882 lost water at the rate of 3.77 cubic feet per second per mile. At that time the canal below Red Bank Creek, about twelve miles from the canal head, was poorly maintained. Water was allowed to spread out in ponds, and a former channel lying parallel to the present canal, and generally very close to it, frequently carried part of the canal waters.

The water surface of the canal was held at an elevation slightly greater than that of the land upon each side. No lands in this section of the canal were irrigated close to the main canal. Ground water was at about 20 feet or more. An indurated clay hard pan lies below the surface soil along this portion of the canal. Here throughout 4.76 miles in length of the canal its average loss by percolation was 3.45 cubic feet per second per mile, a trifle less than in the 12 miles above.

At the point here reached copious irrigation of lands close by the canal, particularly on the south side, had been practiced for

* State Engineer Dept., Physical Data, p. 379.

several years preceding the experiments. Soil is a light sandy loam with ground water at from 7 to 14 feet below the surface. The water surface of the canal was carried at about the elevation of the ground. Land here is very smooth, no high levees are necessary to hold water in its channel. The canal is of uniform dimensions and character, and is better maintained than at points above. These circumstances all combine to reduce the loss by percolation, which here, for 3.75 miles, averages 1.25 cubic feet per second.

Evaporation at the maximum rate above noted would have caused a total loss from the 20 miles of main canal under consideration of a little more than one cubic foot per second, equivalent to a loss of 0.04 cubic feet per second per mile in length of the canal.

The water of Fresno canal flows in natural channels throughout nearly all of the first 19 miles of its course. It lies in the Centerville Bottoms for a mile at its head. Its waters, after passing through Long Cut, are carried into sloughs and depressions, frequently with a levee only along its south bank. Willows, weeds and grasses grow in the water and on the banks of the canal in this locality. In Mud Creek and Fancher Creek the canal water flows in the bottom of a narrow deep channel.

At the time of making the experiments, in June, 1882, there were 95.51 cubic feet of water per second lost from the canal in the first 11¼ miles of its course below the point where it leaves the river bottoms. The loss of water was at the rate of 9.1 cubic feet per second per mile. This great loss must be ascribed principally to the absorbing power of the dry subsoils. There can be no doubt that as ground water rises throughout this district the amount which the subsoils absorb will decrease, and it may be even that the time will come when the flow of the main canal will be augmented at points where its water surface lies far below the surface of the ground.

The ground water plane was already quite close to the ground near Fresno canal in its next section, from the Limbaugh dam (the head of Fresno Mill ditch) to the head of Washington Colony branch, a distance of 7.00 miles, throughout which the total loss by percolation was only 5.20 cubic feet per second, or 0.74 cubic feet per second per mile. Here the depth to ground water ranged only from 4 to 10 feet, and the surface soil and subsoils were kept saturated by water diverted for irrigation. The canal lies in a natural channel, its water surface is generally two or four feet below the surface of the ground.

From the head of Washington Colony branch the main canal

flows for four miles in an artificial channel of uniform dimensions to the railroad. Water is carried about at the elevation of the surface of the ground. The lands adjacent to this part of Fresno canal were practically unirrigated in 1882; ground water was not as near the surface as in the preceding canal division. The total loss in this division of the main canal was found to be 3.81 cubic feet per second, or 0.95 cubic feet per second per mile.

Centerville and Kingsburg canal, for about eight miles after reaching the top of the bluff, has a course parallel to its edge, and never distant from it over one half mile. For several miles, commencing about one mile below Centerville, the canal is only from 200 to 500 feet distant from the edge of the bluff, which is there 20 to 30 feet high. This location in a porous soil and subsoil causes great loss of water by percolation. Nearly 86 cubic feet per second were lost by the canal in less than six miles, and in its seventh mile the canal lost no less than 52.35 cubic feet per second.

(This last result is based on measurements of the flow of water over two wiers, one mile apart, apparently in good condition.)

The average loss per mile from the canal in the 5.50 miles of the upper division examined was 15.63 cubic feet per second.

Other examples of the loss of water from canals and ditches by percolation into the subsoil are the following:

On June 21st, 1882, E. F. Davis was using water for the irrigation of his vineyard in Scandinavian Colony. The water was diverted from the main supply canal into a small ditch about two feet wide. It was conducted past alfalfa fields and vineyard lands a distance of one half mile to the point where it was being used for irrigation. The soil crossed by the ditch is a sandy loam, ground water was at eight feet below the surface. Water was measured at the point of diversion and at the point of delivery in exactly the same way (over small overfall wiers). The amount diverted was 1.70 cubic feet per second, and the loss in transit 0.79 cubic feet per second.

On June 14th, 1882, the orchard on the Gould ranch, north of Fresno, was being irrigated. The water used for this purpose was flowing in a ditch having an average width of three feet. One mile above the point where the water was being used the discharge of the ditch was 2.41 cubic feet per second. The loss by percolation before reaching the point of delivery was 1.42 cubic feet per second. Shade trees were growing along portions of the ditch and its banks were overgrown with grass. The ditch had been in use several

years. The soil through which it flows is a sandy loam five to eight feet deep.

On June 20, 1882, the west branch of the Eggers ditch was flowing 3.52 cubic feet of water per second. It lost 0.76 cubic feet per second in the course of one mile. The ditch had been in constant use for a long time. On the same day the east branch of this ditch lost 0.47 cubic feet per second in the same distance. The flow at its head had been 2.97 cubic feet per second. Both of these branches are about four feet wide. Ground water was 7 to 9 feet below the surface. Soil is a sandy loam, probably about eight feet deep.

On June 26th, 1882, a ditch which leaves Fresno canal in Sec. 5, T. 13 S., R. 21 E., was carrying 5.60 cubic feet of water per second near its head. One mile below the canal was receiving 0.03 cubic feet per second. At the S. W. corner of the S. E. quarter of Sec. 6 it was receiving 0.49, and one quarter mile further west 0.15 cubic feet per second. In the middle of Sec. 11, T. 14 S., R. 20 E., the flow of the canal was only 1.89 cubic feet per second. Its flow had decreased, by reason of the percolation into subsoils, 4.38 feet per second. This ditch has an average width of about eight feet. It carried its water at or a trifle above the level of the ground's surface.

The results of the measurements made by the writer in 1882, then acting in the capacity of Assistant State Engineer, are presented in the following tables, which are taken from unpublished records of the State Engineer Department.*

Whenever the measurements were made at weirs where leakage was suspected, or at points where conditions for gauging were not satisfactory, results have been noted as approximate.

* The State Engineer Department referred to in this paper has been abolished.

LOSS OF WATER FROM THE KINGS RIVER AND FRESNO CANAL.

(Measurements by C. E. Grunsky, Assistant State Engineer.)

Name of Canal or Ditch, and Locality.	Distance Below Head of Canal. Miles.	Discharge. (cu. ft. per sec.) Main Canal.	Diverted	Loss between Stations. (cu. ft. per sec.) Total.	Per Mile.
K. R. & F. C., one half mile below head.	0.50	133.83	.....		
Burns Ditch	1.00	.....	0.25		
Hansen Ditch	4.00	.....	3.23		
Fansher Creek (wastage)	8.00	.....	0.30		
Ditch on South Side	8.00	.....	4.05	43.36	3.77
Ditch on South Side	9.00	.....	0.05		
K. R. & F. C. at Hawkins Weir	9.06	*78.18	.....		
Wastage	.....	.....	0.15		
Ditch on South Side	11.50	.....	2.04		
K. R. & F. C. in Red Bank Creek Flume.	12.00	80.40	.....		
Dog Creek (wastage)	13.25	.....	0.15		
Ditch on North Side	16.00	.....	3.36	16.50	3.48
Eggers Ditch	16.75	.....	4.67		
K. R. & F. C. at Eggers Weir	16.75	55.72	.....		
K. R. & F. C. West Line of Section 17.	17.75	*49.56	.....		
Ditch South Side	17.80	.....	3.08		
Scand. Col. Ditch	18.25	.....	3.86		
K. R. & F. C. at Upper Scand. Col. Weir	18.25	*36.74	.....		
Scand. Col. Ditch	18.35	.....	1.46		
Scand. Col. Ditch	18.50	.....	2.42		
Scand. Col. Ditch	18.60	.....	1.00		
Scand. Col. Ditch	18.70	.....	2.39	4.44	1.25
Scand. Col. Ditch	18.80	.....	14.50		
K. R. & F. C. Lower Scand. Col. Weir.	19.00	*25.51	.....		
Big Creek (wastage)	19.25	.....	1.50		
Wastage	.....	.....	0.20		
Ditch on North Side	19.75	.....	0.43		
Cooper & Helm Ditch	20.25	.....	8.71		
K. R. & F. C. at Cooper Weir	20.30	11.73	.....		

*Approximate.

LOSS OF WATER FROM THE FRESNO CANAL.

Name of Canal or Ditch, and Locality.	Distance Below Head of Canal. Miles.	Discharge. (cu. ft. per sec.)		Loss between Stations. (cu. ft. per sec.)	
		Main Canal.	Diverted	Total.	Per Mile.
Fresno Canal at Road Bridge	1.25	381.00	.....		
Centerville Branch	1.75	.....	17.80		
Lone Tree Branch	3.25	.....	69.39	95.51	8.49
Ditch on South Side	5.00	.....	0.50		
Limbaugh Dam Ditch	12.50	.....	58.72		
Fresno Canal at Limbaugh Dam	12.50	139.08	.....		
Briggs Canal	14.00	.....	0.30		
Eisen Canal	14.00	.....	14.09		
Fresno Canal at Hobler Dam	14.00	107.88	.....		
Easterly Ditch	17.25	.....	5.60	5.20	0.74
Malters Ditch (North)	19.00	.....	6.30		
Malters Ditch (Central)	19.00	.....	1.69		
Washington Col. Branch	19.50	.....	45.50		
Fresno Canal at Head of Wash. Col. Branch	19.50	60.40	.....		
Fresno Col. Canal	23.50	.....	14.15		
North Central Col. Canal	23.50	.....	13 88	3.81	0.95
Main Central Col. Canal	23.50	28.16	.....		

LOSS OF WATER FROM THE CENTERVILLE AND KINGSBURG CANAL.

C. & K. Canal, ½ Mile Below Head	0.50	346.00	.....		
Ditch on West Side	5.50	.....	5.06	85.94	15 63
do	5.75	.....	4.00		
C. & K. Canal at Weir, in Sec. 23	6.00	251.00	.....		
Garfield Canal	7.00	.....	26.65	52.35	52.35
C. & K. Canal at Weir, in Sec. 26	7.00	172.00	.....		

It is incontrovertible that, even without an increase of the amount of water annually brought into the district, the area irrigated may be increased until irrigation produces no further permanent changes in the elevation of the ground water plane.

Without attempting to express in detail the acreage irrigated per cubic foot per second of the average flow of water for each canal, it is interesting to note that the total volume of water brought into the vicinity of Fresno during the twelve years, 1879 to 1891 inclusive, at a very low estimate would have covered the entire 300,000 acres of the region through which the canals send their branches to an average depth of eight tenths of one foot per annum. It would have covered the 60,000 acres, to whose surface water is actually applied to an average depth of 4.5 feet per annum, or to a total depth of 54 feet. Some of this water has of course been consumed in sustaining plant life, more still evaporated, but the most of it permeates the subsoils of the irrigated region and of the lands toward the west.

That portion of the Kings River delta which lies south of the main channel of the river is known as the Mussel Slough Country. Innumerable sloughs, former high-water channels of Kings River, course through this region from north to south. The heads of many of these have long been filled with river deposits.

Others have more recently been artificially closed. A great many have been made parts of the distributing system of the irrigation works of this region. The surface of the Mussel Slough Country slopes from northeast to southwest at the average rate of three to four feet per mile, which is only about one half the fall of the ground's surface in the vicinity of Fresno. It is the most nearly level of all the irrigated regions in the San Joaquin Valley.

The soil of this region is all sedimentary. Most of it is sandy loam, varying somewhat in texture and color in different localities. It is sandiest toward the east and northeast, heaviest toward the west and south, where it merges into the peaty clay of the swamp land belt. To the northeast and southwest of Grangeville, a strip of land several miles wide extends through this region, whose soil is a dark rich loam, generally considered the best soil in the vicinity. The soil is generally of great depth. It alternates with thin layers of soft clay. Hardpan is rarely found in this district.

Before the construction of the irrigation canals in the Mussel Slough Country, the water table was at ten to eighteen feet below the surface. It was found at greatest depth in its eastern and south-

ern part. Irrigation very soon brought ground water close to the surface, and throughout the irrigated portion of the district it does not now sink to over eight feet below the surface. It has an annual fluctuation, rising during the spring months when the canals are full of water, and falling again in the fall of the year. In some localities this rise is so great that water appears in the depressions and stands in them until the flow of water in the canals decreases. The sinking of the ground water plane to a lower level after the irrigation period, is due to two causes, viz: to the evaporation of water from the surface of the ground, and to the flow of water through the subsoils to points of lower level.

That evaporation is an important factor cannot be doubted, as experiments made at Kingsburg show the mean annual evaporation from an open sheet of water to be about 4.3 feet per annum, and about 3.5 feet for the six months, May to October (inclusive). The evaporation from saturated soils takes place at about the same rate. Moreover, when water equivalent to a certain depth of water evaporates from the surface of the ground, it must cause a lowering of the water table to a much greater extent, because soil water fills only the interstices between soil particles in the strata which it permeates.

The Mussel Slough Country is supplied with water from Kings River and from Kaweah River. The former supplies water through Peoples, Mussel Slough, Last Chance, and Rhoads canals to the northern, central, and western portions of this region, while the latter supplies water to its eastern parts through the Settlers and Lakeside canals. For about six months each year, commencing with February, Kings River furnishes an abundance of water for the canals leading from it.

The canals from Kaweah River are not so copiously supplied with water, because Kaweah River is subject to greater irregularities of flow than Kings River. Their period of flow is not so long as that of the Kings River canals, and is largely dependent on the conditions of the diversion of water at the head of St. Johns Channel, where conflicting interests of different irrigated regions have given rise to repeated modifications of natural channels. Ordinarily the flow of Settlers and Lakeside canals begins in January and continues until the end of June.

The total amount of water ordinarily supplied to the Mussel Slough Country by the canals above enumerated, is sufficient to cover the entire region through which these canals or their branches extend, to an average depth of one to two feet per annum. It is

sufficient to cover the land which was actually in cultivation in 1885, in this region, to an average depth of about four feet per annum.

The flooding of lands to accomplish irrigation in this district is rarely resorted to. It is done only in cases of extreme necessity when water does not become available for the canals until late in the season, and the ordinary process of filling the subsoils with water would engender the loss of too much time.

The usual method of irrigation in this region is the following: While trees and plants are in need of water, the main canals, their branches and small irrigating ditches are kept as full of water as the available supply will permit. From the canals and ditches the water sinks into the porous soil, causing the ground water plane to rise to within three or four feet of the surface, thereby bringing moisture to within reach of the capillary attraction of the surface soil and into contact with the roots of trees and vines and other plants. Sometimes low places become too moist under this system of irrigation, and it even happens that water rises above the surface in low places, forming ponds which disappear after the irrigating season has passed.

Before the construction of the irrigation works of this region, ground water was generally at fifteen to eighteen feet below the surface of the ground. Irrigation caused it to rise until now depth to water varies with the seasons from a greatest depth of seven to ten feet during the fall months, to one to four feet in the spring. The annual fluctuation is the direct result of irrigation. It is more or less rapid according to character of the soil and according to distance between ditches from which the water sinks into the soil.

Locally this system of irrigation is generally referred to as irrigation by percolation, and the erroneous idea prevails that the surface of the ground remote from irrigation ditches becomes moist during the irrigating period by reason of direct horizontal percolation of water from the sides of the ditches.

For the irrigation of grain or alfalfa, it is customary, if the land be at all uneven on the surface, to carry distributing ditches along the highest points of the ground. From these water is drawn into irrigating ditches three to six feet wide, one to two feet deep, which are cut with a slight fall out upon each side from the distributing ditches, and are from 300 to 600 feet apart. These irrigating ditches are either temporary or permanent. If temporary, they are usually plowed in after each irrigation, and are re-opened for the next one. When orchards and vineyards are to be irrigated the ditches are con-

Irrigation by Filling Subsoils with Water.

Mussel Slough Country.

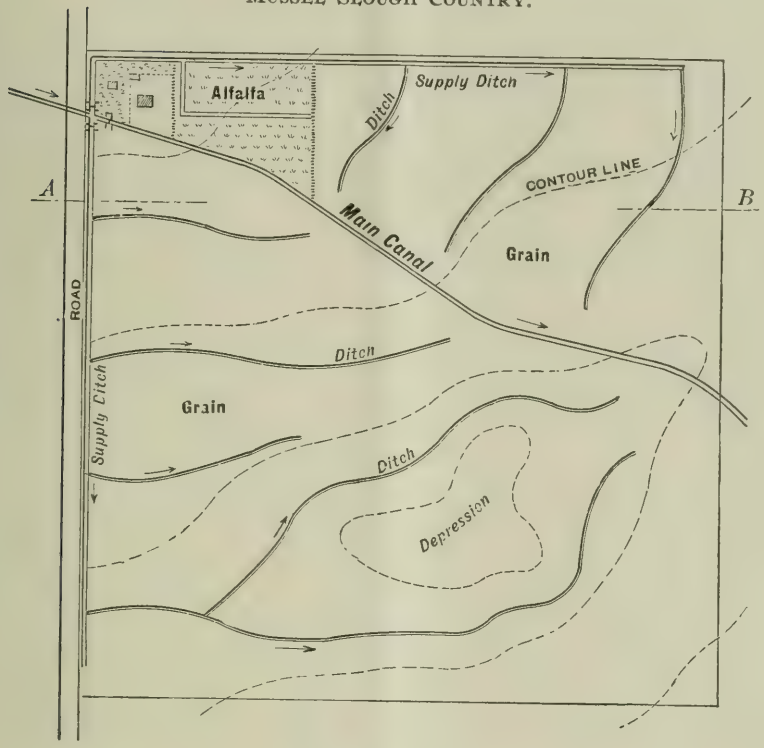


Fig. 1. Plan.

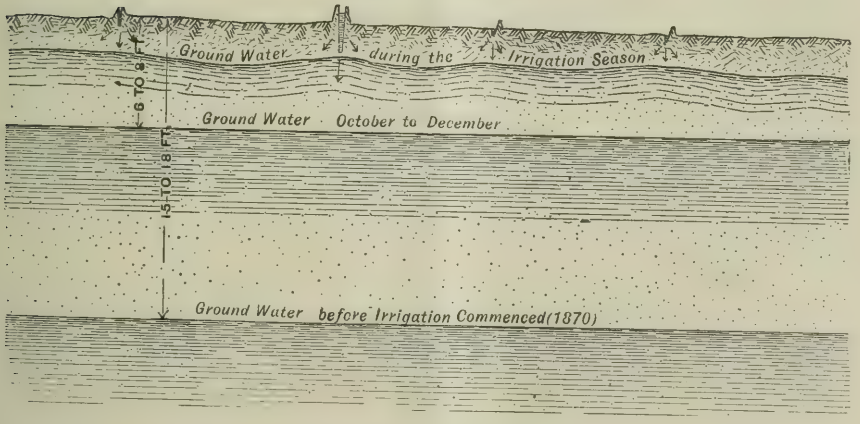

Ground Water during the Irrigation Season
6 TO 8 FT.
Ground Water October to December
15 TO 18 FT.
Ground Water before Irrigation Commenced (1870)

Fig. 2. Section.

structed in straight lines between the rows of trees or vines whenever possible.

The method of irrigation as practiced in the Mussel Slough Country, involves an upward motion of moisture from the subsoils to the surface. The water which finally accomplishes the irrigation of any particular spot may have been a part of the soil water for many years, and may therefore be highly charged with soluble salts. The water fresh from the ditches sinks vertically downward, displaces and commingles with the soil water vertically under the ditches, and by hydrostatic pressure forces the water remote from the ditches to rise.

As the water, thus rising near to the surface, is brought further upward by capillary attraction, and finally evaporates at the surface, and although the quantity of alkaline salt in solution may be small, the long continuation of this system of irrigation must cause a gradual increase of alkali in the surface soils.

The white efflorescence so frequently making its appearance on alkali soils at the commencement of our long dry seasons is directly due to this cause, whether the upward moving water be supplied artificially or otherwise. To the same cause must be attributed the great accumulation of alkali in the strip of land extending lengthwise through San Joaquin Valley, at and near the margin of its flood line. Possibly as much alkali is brought to the surface by the rising moisture nearer the river, but the more frequent inundations carry it off, and free the soil from an injurious surplus. Not so at the extreme flood line, where water is frequently supplied to the subsoils, and moisture may rise to the surface without the surface receiving any benefit from an inundation.

It is evident in this connection that the alkali of surface soils may be variously affected by rains, according to the amount of rainfall and its duration. A light rain, which wets the ground only to the depth of a foot or two, may dissolve the efflorescence and all alkali crusts on the surface, and carry the salts back into the soil. Some of them will return to the surface in the course of time when the moisture returns and is evaporated at the surface. A long-continued steady rain may send a large amount of water vertically down through the surface soils to ground water. The salts leached out of the surface soil will pass into the ground water, and may, perhaps, be carried off to some other region. A sudden heavy rain on the other hand may dissolve the salts on the surface, and flowing in depressions, creeks and sloughs carry it into streams that flow to the

ocean. Only in the latter case is there any certainty that the alkaline salts carried off have been permanently disposed of.

It is obvious that an accumulation of alkali at the surface is most to be feared where there is the most upward movement of water. This being the case it follows that, as in the Mussel Slough Country, subsoils are unusually rich in mineral salts, great injury to the quality of the surface soil may be done by irrigation as practiced there, unless the necessary remedial measures be adopted.

Careful inquiry establishes the fact that some injury has already resulted from this cause, that many fields whose soil was, a few years ago, of excellent quality, now have soil too strongly alkaline to produce good grain crops, and that with the increase of alkali in its favor salt grass is encroaching to an undesirable extent in many alfalfa fields. There seems to be no limit to the extent of damage which may result from this cause unless the method of irrigation is properly modified.

The simplest remedy for this evil, suggested by its cause, is to secure a preponderance of the downward motion of moisture. If this can be done, more of the salts leached out of the soils by water will move downward away from the surface than upward toward it. The quantity of alkali at the surface, where it is most injurious, will necessarily be decreased. The remedy will be made still more effective if subsurface drainage be resorted to, whereby the water descending to the subsoils through the surface soil can be in large part carried off into natural drainage channels.

The downward motion can be secured by copious flooding. Ordinary flooding may prove an injury instead of a benefit, because in the case of ordinary flooding the soil is wet to such slight depth only, that capillary attraction and the hygroscopic properties of some of the alkaline salts cause a return of all, or nearly all, of the water that has been put on the surface, and it returns from the saline subsoils freighted with more alkali than it carried down to them.

By flooding copiously and draining off the water from the surface of the land into natural drainage channels, some of the salts can be permanently disposed of, but ordinarily, the process of flooding affords ample time for the water which wets the surface layers of soil to dissolve the salts and carry them into the ground where they remain, while the water which holds the least salt in solution is drained off from the surface. Flooding and surface drainage is for this reason an imperfect remedy.

Deep plowing always mitigates the evil, because the alkalis accumulated at the surface are turned under, and, as is well known, the alkali at the surface has the greatest power to do harm to the tender stems of young plants.

By frequent tillage capillary attraction from the surface downward is interrupted and the amount of moisture reaching the surface to be there evaporated is diminished, consequently the amount of alkali brought to the surface is thereby reduced.

The phenomena above instanced of gradual and of periodical fluctuations of the surface of soil waters are directly due to underflow, to the movement of waters in permeable soils. Those of the Fresno region are controlled by the resistance opposed to the subsurface flow of waters westward toward the trough of the valley, those of the Mussel Slough Country more directly by methods of irrigation and rate of evaporation, as well as by the forces opposed to a movement through pervious soils toward the bed of Tulare Lake.

Although the intimate relation existing between irrigation and the elevation of the plane of subsurface water in the vicinity of Fresno, as well as in the Mussel Slough Country, has been clearly demonstrated, and is quite well known to the residents of these districts, it is somewhat surprising that it is the rule, rather than the exception, to draw water for domestic use from relatively shallow wells which fully admit ground water.

Twelve out of thirty-four wells which the writer visited in 1885, a few miles south of Fresno, were not cased with water-tight casing. The water in them was turbid, clearly unfit for domestic use, standing in some instances within four to six feet of the ground's surface. Of the others but few exceeded sixty feet in depth. Owing to the great depth of porous formations in this vicinity it is safe to say that surface waters were not entirely excluded from any of them.

In discussing salubrity of an irrigated region the first inquiry may well be directed to source of water supply for domestic use rather than to the uncertain conditions, such as humidity of the atmosphere, resulting from the artificial distribution and application of water.

USE OF COAL OIL IN STEAM BOILERS.

By W. A. Doble, Mem. Tech. Soc.

[Read August 4th, 1893.]

It is not the object of this paper to cross swords with the manufacturers or sales agents of any boiler compound, neither does it recommend or condemn any. Its sole object is to bring before the Society, an account of the use of coal oil as a boiler scale preventive by our company.

We will not treat this subject from a scientific standpoint, and will not attempt to deal with the chemical action of the various resolvents on the lime, etc., in the water, nor their effect on the material of which the boiler is constructed, but will merely relate our experience with it as an ordinary practical shop experiment covering a period of over six years.

We use a plain tubular boiler, 44 inches diameter, 14 feet long, with thirty-eight 3-inch tubes, and a grate surface of 16 square feet. It generates steam for a ten-hundred-weight steam hammer, and also a vertical engine coupled direct to a forging press. We consume on an average 2,000 pounds Wellington screenings per day of ten hours; this includes the coal used in banking the fire over night. We wash out the boiler every two weeks, and bank the fire over the intervening Sunday.

About the year 1886 or 1887 we noticed in one of the technical papers an account of an experiment tried on the boiler of an eastern municipal pumping station, of using coal oil as a scale preventive, where they had been bothered with a very hard scale which clogged the tubes, it being a water-tube boiler. As we remember it, the first experiment was to find if the coal oil would stay in the water any length of time, the general belief being that it would evaporate rapidly with the steam. A little coal oil was put in a large test tube partially filled with water, and the tube placed over an alcohol lamp. The heat caused the water to boil violently, and the globules of oil circulated round with the water, and could be distinctly seen. Of course some of the oil did evaporate, but the greater part remained in the water. The actual test was so successful that we concluded to try it, as our experience with the compound we were then using was not satisfactory.

Our method is as follows: When we wash out the boiler and refill it we put in two quarts of the cheapest coal oil that we can

buy, generally about 110° fire test. Below the suction pipe of our injector, and connected with it by means of a **T** and two cocks, we have a well, the capacity of which is about a quart. In about three or four days we fill this well with the oil, and the feed water passing over the connection gradually displaces the oil and carries it into the boiler, usually taking three to four hours to displace all of the oil. In about three or four days we repeat the quantity, using in all about one gallon of oil to each run. This includes the two quarts placed in the boiler after being hosed out.

Before we tried the oil we were using a well-known scale resolvent, and in the language of the firemen "the boiler was as clean as new, because the scale was not so thick but that we could count the rivet heads." Of course the bottom sheet of the boiler was comparatively clean where you could get at it to hack the scales off, but up among the tubes, and on the shell of the boiler back of the tubes, and on the tube heads, the scale was very thick and hard. Since we have used the oil we have not found it necessary to use any mechanical means to keep the tubes and tube heads in order. Of course the oil does not prevent the precipitation of the lime that is in the water, but it is in the form of loose scales and does not adhere to the iron. Usually it collects on the crown sheet in a little scattered pile, just as it would gradually settle while the circulation of the water became less and less as the fires cooled down.

The tubes, shell, and tube sheet are practically clean and without any scale whatever. Sometimes there will be a little particle of thin scale, but the next time we clean out that collection of scale will be gone, and maybe a little collection will have settled on another spot, but it is always thin, not over $\frac{1}{32}$ in., and is loose and can readily be picked off with the thumb nail. Our boiler is now over eight years old, and we have not put any repairs on it other than to put in new grate bars and fire-door liners. The duty is heavy, as the steam hammer is a very irregular consumer of steam, and the vibration and concussion is severe on the pipes, settings and connections, so that we consider this a very fair record. Will say also that there is no pitting or corroding, but the plates are clean and bright.

DISCUSSION.

THE CHAIRMAN.—"Mr. Doble has called our attention to a very interesting fact, and as I see several members present who have had considerable experience with boilers and boiler-scale compounds of

different kinds, I would be pleased to hear from them. I think this a very broad and interesting subject."

MR. A. D'ERLACH.—"I would like to hear ideas expressed in explanation of this phenomenon. The scale appears to be firm, but does not seem to stick. My present idea is that some portion of the oil lines the inner surface of the boiler, and that that prevents the scale from sticking."

MR. MANSON.—"I think there would be a two-fold action, the oil would not only adhere to the sides of the boiler and tubes, but it might also adhere to the particles of scale as soon as they were formed."

MR. LEAR.—"In the year 1887, I think it was, while I was engaged in some chemical work in the East, an engineer brought me some scale taken from the tubes of a boiler where no compound had been used, and, afterwards, some of the same deposit when coal oil had been used in its crude state. There was no difference whatever in the chemical composition. I did not have time just then to follow up the matter. I questioned the professor of chemistry about the matter, and he said the action was entirely a physical one, that the scale was the same in both cases."

MR. A. D'ERLACH.—"That seems to be in support of my idea, which is that the action is physical."

MR. M. P. BOSS.—"I have been running two standard boilers for five years near the City of Mexico, and for two years of the time I have been using crude petroleum in the boilers to prevent scale. The water there is very bad. While we used the oil we had no scale, it was more like mud, and blew off very readily. But during all that time we were troubled very much with leaking of the tubes, we could not keep them tight. I do not know how this is explained, unless it is the cleaning away of the dirt which may have gathered and prevented leaking. The boilers were made in San Francisco, and were first class."

MR. DOBLE.—"Before we used coal oil we had been using a scale resolvent; one day the agent came around after we had commenced using coal oil, and upon my telling him of it he said he was very much surprised that we should do so. I asked him why, and he said 'do you know it will take the scale off so clean that the boiler tubes will leak?' I replied that if our boiler was held together by scale it was time to get a new one. He has not been around to see us since."

REGULAR MEETING, AUGUST 4, 1893.

PROCEEDINGS.

MINUTES.

Called to order at 8:30 P. M. by Past President Manson.

The minutes of the last regular meeting were read and approved.

The following gentlemen, having been balloted for, were declared duly elected members of the Society.

Julius H. Striedinger, Civil Engineer.....San Francisco, Cal.

A. Patton, County Surveyor.....Tulare County, Cal.

The following names were proposed, and referred to the Executive Committee :

For Members :

Edgar N. Eager, County Surveyor, Solano County, Cal.; proposed by Adolph Lietz, E. T. Schild and H. C. Behr.

John S. Walker, Civil Engineer, Apia, Samoa; proposed by Julius H. Striedinger, Otto von Geldern and Geo. F. Schild.

The committee on the Midwinter International Exposition reported that Mr. Alexander Badlam, the Secretary, had been called upon, and that officially the offer to coöperate with the General Committee had been accepted, and that the Committee from the Technical Society would be notified in due time when their services would be desirable. For the present nothing of a technical nature is required in the organization of the Exposition.

A letter was read from J. A. Woodson, for the Committee of Promotion, asking that two delegates from the Technical Society be sent to attend a meeting of the State Road Convention, to be held at Sacramento, September 7th.

The Chairman stated that the President had appointed Messrs. Julius H. Striedinger and O. H. Buckman to act in that capacity.

The following report of the committee having under consideration the merging of the California Electrical Society into the Technical Society was read :

SAN FRANCISCO, CAL., July 7, 1893.

TO THE TECHNICAL SOCIETY OF THE PACIFIC COAST :

Your committee, appointed to confer with a committee from the California Electrical Society, for the purpose of considering upon

what basis a union of the two societies might be effected, hereby respectfully reports:

That such union might be brought about by admitting the members of the California Electrical Society in a body, respectively as full, associate and junior members of the Technical Society, upon a classification made by themselves on the basis of the qualifications as laid down in the constitution of the Technical Society, the classification list to be submitted to and approved by the Board of Directors of the Technical Society.

That, in such admission of the members of the California Electrical Society, the usual form of election be waived.

That no initiation fee be exacted.

In order to effect the absorption of the California Electrical Society upon the above basis, your committee suggests that the Board of Directors be authorized to examine and, if satisfactory, approve the classification list of the members of the California Electrical Society as by it submitted, and that on their recommendation the union be effected by unanimous consent at a regular meeting of the Technical Society.

G. W. Dickie,
John Richards,
D. C. Henny.

Upon motion the matter was referred to the Board of Directors, with full power to take action on the basis as outlined in the report.

A communication was read from Past President John Richards, proposing for honorary membership in the Technical Society Chief Naval Constructor Theodore D. Wilson, U. S. Navy. The resolution was accepted, and the communication referred to the Executive Committee for action and approval.

To draw suitable resolutions of respect in memory of the late P. J. Flynn, the President had appointed the following committee of Los Angeles members: Fred Eaton, Chairman; Burr Bassell and Valentine J. Rowan. A communication was read from Mr. Bassell, wherein the Committee asks for an extension of time until the September meeting. The request was granted.

Mr. W. A. Doble read a paper entitled: "Use of Coal Oil in Steam Boilers," which was discussed.

Mr. Marsden Manson read a paper written by President Grunsky, entitled: "Notes on Artesian Water, and the Effect of Irrigation on Subsurface Water in the San Joaquin Valley." The discussion of this subject was postponed until the next regular meeting on account of the absence of Mr. Grunsky.

Adjourned. Otto von Geldern, *Sec'y.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME X. No. 8.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

THE EXISTING STATE OF THE FLUID FUEL QUESTION.

BY ADMIRAL SELWYN.

[Read September 1st, 1893.]

About twenty-six years ago, in 1867, I took up the problem of oil burning at the point at which I found it, from the labors of Schapoosky, in Russia; Mr. Mallet, C. E., Messrs. Field and Ayden, C. E., and others in England; and Colonel Foote and several others in the United States, about 1865, of liquid or oil fuel as compared with coal. At that time the efforts of all the inventors on the subject, and there were many, were directed to burning the oil without too much smoke, and getting an evaporative duty up to once and a half, or at best twice, that of coal. Now as the calorific value or evaporative duty of coal is *theoretically* nearly sixteen pounds of water by one pound of coal when the coal is of the very best quality, and the *practical* duty is about one half of this, or eight pounds of water per pound of best coal, the whole being a sadly imperfect operation at best, resulting in the production of ashes, soot, smoke and slag, it seemed as if, should oil be burnt without anything of the kind, a large advance in the production of steam must be the result. From that time to the present I have made many experiments on the full scale on all kinds of land and marine boilers, and I am enabled this evening to give you an account of the results I have obtained and demonstrated for some years past.

These results are so far in advance of everything that has been done elsewhere, either in Russia, England or the United States, that I hope engineers, whether by land or sea, will take deep note of

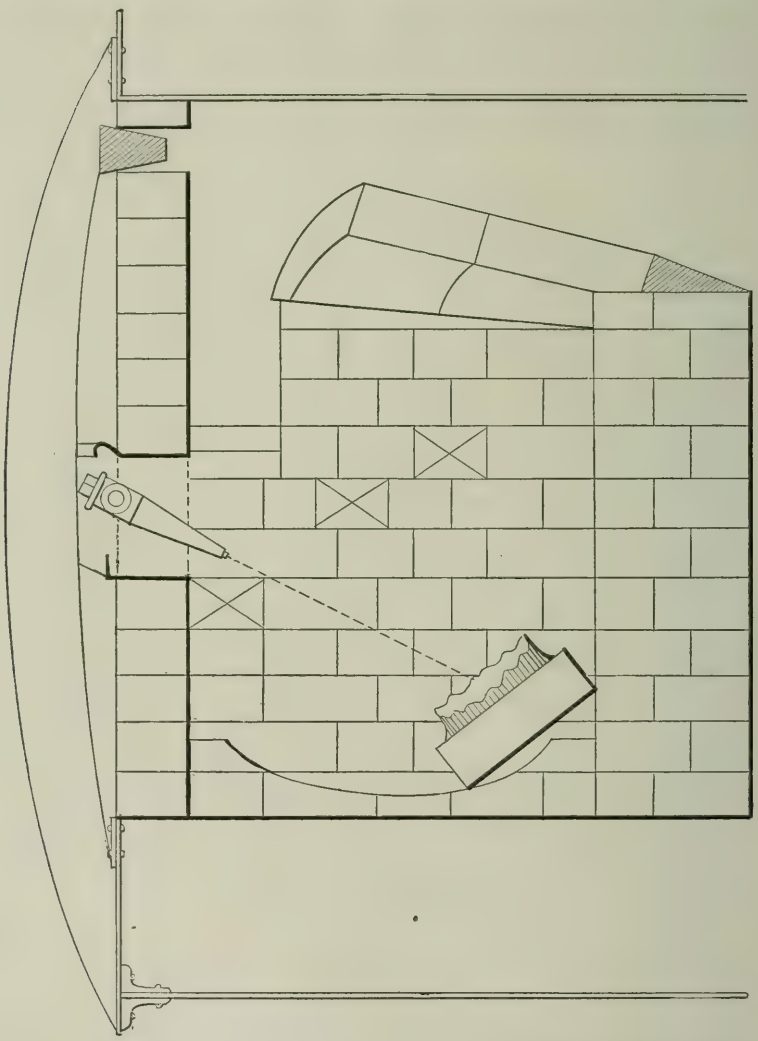


FIG. 1. SHAPE OF THE BRICK FURNACE FOR BURNING FLUID FUEL.

them, and the extremely simple methods by which they are obtained. To those engineers I need hardly say anything to remind them that of all engineering work the basis is fuel, and that therefore there does not exist an engineer in the world who has not an

interest in the discovery of a cheaper, or more easily managed, fuel, and when I say, that with the means at present easily available, we can have six times the evaporative duty of coal without any stoking or stokers, for no more weight carried, and little, if any more, cost per ton, they will, I am confident, think the subject an object of legitimate discussion in a technical society. On the blackboard I have given a rough sketch of the necessary appliances (for which there are now no existing patents) used by me for many years past. Any engineer can pull out his coal grate, and put the furnace in, in forty-eight hours at most, and it will not take him much longer to make the injector (atomizer), and fit the pipe and tanks. It can all

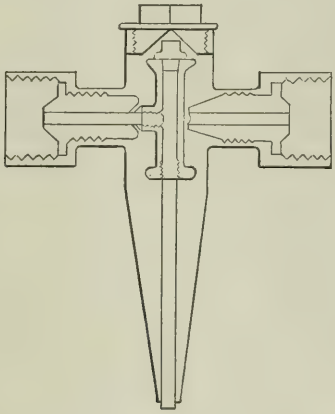


FIG. 2. THE INJECTOR OR ATOMIZER.

be pulled out, and the boiler be burning coal again if desired in twenty-four hours. But I do not believe anyone would ever wish to do it after he had once tested the result obtainable, and my experience is not a small one as it extends over more than a quarter of a century.

Having said this much you will perhaps permit me to go a little into the root of the matter, for no one can do anything thoroughly well unless he knows the reason why he does *that* rather than anything else. There is science in the swing of a shovel of coal, why should there not be in the use of a more perfect fuel? There are three kinds of fuel, solid fuel, as coal or wood; liquid fuel, as oil or alcohol; gaseous fuel, natural or artificial, but all must take a gaseous form before they can unite with the great supporter of combustion, the oxygen of the atmosphere. To effect this change work

must be done, and this work in the case of a solid fuel requires, according to the best authority, six units of heat (or pounds of water evaporable) out of the sixteen available. There then remain only ten units utilizable. If, as the same authorities are agreed in saying, two more units disappear in waste heat going into the stack to produce draft enough to supply the air, no more than eight units remain to give us evaporative duty, and less, if after all there is smoke and soot, denoting an imperfect combustion. It is not extraordinary then that only eight pounds of water can be evaporated by the use of one pound of the best steam coal in practice.

In any case where thick black smoke passes off, as much as fifty per cent. of the calorific effect is probably lost. We may now pass on to the consideration of liquid fuel. Here we have a substance consisting of carbon as before, but with a considerable proportion of hydrogen. Besides this it is on its way to become a gas, the atoms composing it are more widely separated already, and therefore not so much work disappears in effecting their union with oxygen, instead of six units, less than four units will be wanted. Owing also to the hydrogen present the theoretic calorific value will be twenty-one instead of sixteen, twenty-one less four leaves seventeen units for evaporative duty instead of ten, and 16.9 pounds of water were, in 1869, actually evaporated per pound of oil used in experiment with a boiler (of ordinary marine type at that time) of 160 nominal horse power, burning heavy oil of lubricating quality, and having a specific gravity greater than salt water. This I believe to be the highest duty of which *oil alone* is capable. The experiments lasted for nine months, were undertaken for the British Admiralty, and were under the close supervision of their own engineer the whole time.

I have all along insisted that oil of a less specific gravity than salt water must not be used on board ships whatever may be done on land. The ship's hold is practically a confined space, in which if any gas can be given off at a less temperature than 300° Fahrenheit it may form an explosive mixture with the air below deck, and blow up the ship. The heavy oil of which I speak will not give off gas at less than 360 Fahrenheit, and cannot be lighted, or burnt at all, unless it is atomized by air or steam, or else supplied with a wick. It is even less dangerous on this account than coal, which has often been known to take fire spontaneously when containing pyrites.

There is a most important difference between the blowing in of

oil by means of steam as compared with blowing in with air, which is not by any means generally understood. The steam contains hydrogen, and the air does not. One pound of steam (considered as water) is required to blow in one pound of heavy oil at common pressures, up to fifty or sixty pounds on the inch, less as that pressure is increased. This, by some persons, has been complained of as if it were a heavy tax on the boiler using oil. But as a fact, for which I can vouch, each pound of steam so used produces the full calorific effect due to its hydrogen, and adds to the duty of the oil fuel seven more units of heat, bringing the evaporation up to twenty-two or twenty-three pounds of water (measured from the supply tanks) per pound of oil and steam burnt. The hydrogen finding incandescent carbon in the furnace unites with it to form hydro-carbon, and is then burnt with the above useful effect. Roughly, in this manner, there can be obtained three times the evaporative duty of the best steam coal. Now the hydrogen being a gas is "fluid" but not "liquid" fuel. Being a gas the loss in dissociation is not more than one unit of heat, and it readily combines oxygen, as we know from the oxy-hydrogen blowpipe, to produce intense heat. We have therefore entered on the use of pure gaseous fuel derived from water, and automatically produced.

Why, as the French say, "should we stop on so good a road?" 214 times its own volume of air is being delivered into the furnace by the steam, which also blows in and converts the oil into spray. Four fifths of that air is hydrogen, the strongest known combustible. When in the form of nitrous acid it can be shown on the highest chemical authority to be capable in combination with six atoms of hydrogen of evolving 329,000 heat units.

At any rate I have long ago seen it burnt, and burnt it myself under ordinary marine and Cornish boilers with a result of measured evaporation from oil, hydrogen and nitrogen together, of no less than forty-eight pounds of water per pound of oil used, plus the above gaseous substances, which cost just nothing at all.

This is six times the power of evaporated, "or calorific value," of the best steam coal, and will enable future engineers to drive a steamship round the world, or a railway train across the continent, at full speed, with one supply of fuel weighing no more and occupying less space than a single supply of coal.

I am not yet prepared to give full information as to how the nitrogen is burnt, nor as to higher duty than six times coal, which is no doubt possible, but no changes are needed in the furnace, or the

injector shown, nor any other which cannot easily be carried out by a ship or railway engineer. All the figures I have given are taken from notes made during the actual working, and were checked by civil and naval engineers, to whom my work was always openly shown, is as far as I could be certain of the causes and effects. Of course I drew many inferences, which I am slow to bring forward till everything can be tested and proved to complete demonstration, knowing well how necessary such caution is before asserting a new truth or science, or indeed any departure from long established practice however absurd it may become in the light of later discoveries. As far back as 1869 I had not only heard of but carefully examined cases of high evaporation, but I could never find anyone who knew what cause to assign it to, till I actually saw in my own furnace the apple-green flame of burning nitrogen, as described by some of the older chemists (who knew well that it was a combustible of great power, though gun cotton and dynamite had not then been invented) and got forty-eight pounds of water evaporated per pound of oil used by the assistance of the hydrogen of the steam and the nitrogen of the air. These latter then, their nature and their effects have justified. I submit the new nomenclature, I have used "fluid" instead of liquid fuel, for while all liquids and all gases are fluid at our ordinary atmospheric pressure, the gases are not liquids, and such a compound fuel as I have been describing cannot properly be comprised under the term of liquid fuel.

Being fully impressed with the cardinal truth that a paper should only be "a peg to hang a discussion on," I will no longer detain those present from a discussion which I expect will be so profitable to the steam user, and therefore I hope to many among the engineers and technologists generally.

After the reading of the paper, Admiral Selwyn referred to a diagram on the blackboard, which illustrated the shape of his particular furnace, and the shape and arrangement of the injector or atomizer, which he explained to the Society in detail, laying particular stress upon them as the essentials in his method of combustion.

DISCUSSION.

Mr. Geo. W. Dickie.—"Mr. President, I would like to say a few words on this subject, because some of the statements made by the Admiral are rather astounding to me, especially in regard to the efficiency of liquid hydro-carbon fuel, such as the waste of petroleum.

I met in Chicago, Signor Soliani, of the Italian navy, who presented a paper to the Engineering Congress on this subject, and the result of a series of experiments that had been made on several vessels of the Italian navy. I may say that he is an enthusiast on the burning of liquid fuel, especially on war ships, for several reasons that do not apply in the merchant service. It can be carried on in places where coal could not be stowed, and has the advantage of easy transportation from one part of the vessel to the other.

Quoting from Signor Soliani's paper, he says:

'Experiments were made by Mr. Urguhart, at that time director of the Baku-Tiffis, and the Guazi-Tzaritzin railways, and by Messrs. Nobel Brothers, to ascertain the heating power of oil fuel. One kilogramme of oil fuel when burning, yields about 11,100 units of heat (metric system) against about 7,700 given by coal. The heating power of the oil fuel compared with that of coal ought therefore to be in the ratio $\frac{11100}{7700} = 1.44$ to 1.'

He also mentions experiments made in England under the supervision of Mr. Sennett, of the British navy. These I have examined myself pretty closely. He experimented both with steam and compressed air in the atomizing of the oil, and he thinks there is some advantage in the use of steam. The practical ratio as given by Mr. Sennett, of oil fuel compared with coal, was 1.6 to 1. This statement compared with the statement to-night by the Admiral, is rather astonishing, when he states that the evaporating power of liquid fuel is equal to 6 to 1."

Admiral Selwyn.—"Pardon me, I said fluid fuel, not liquid fuel."

Mr. Dickie.—"In all discussion of fluid fuel we must take into account one fact, which acts very decidedly against its adoption; that is, the amount of this fluid that is available. On board ship we must have a fuel that will not ignite under 160° to 200° Centigrade. It would be dangerous to carry otherwise. The American product of this fuel is very small. Most of the residium or waste from petro-

leum is consumed in our refineries, and the percentage is very low. In the Caucasus the percentage is much higher, running all the way from 17 to 30 per cent. The total product of this fuel in Russia does not exceed a million tons a year. It has been very successful in the Caspian Sea and on the Volga because it is cheap there. It is sold at three francs per ton. The country nearest thereto, that would reap the greatest advantage from its use, would be Italy. But there the price is from 27 to 38 francs per ton, which makes it impractical, unless for some special purpose, as compared with coal.

The experiments that have lately been carried out have been very extended and thorough, and the fluid fuel has been credited with all the saving in labor, the saving of dirt and ashes, and similar advantages, and yet we have reluctantly come to the conclusion, after a series of experiments extending over two or three years, that as matters are at present, without a vast increase of the product, and without a cheapening of it in the maritime stations where it would be used, coal not only holds its own against it, but the percentage in favor of coal is very high indeed. In fact, from the statements made to me by Signor Soliani, the difference is as two to one.

I make these statements to-night because I am fresh from a lengthy discussion of this subject by some of the ablest men who have taken it in hand.

There is a vast amount of petroleum fuel used in this country in its crude state, but it would not be desirable on board ship. We have used it here in San Francisco Bay, and the results have been rather disastrous on account of the volatile nature of the fuel. Petroleum fuel is used for the production of steam at the Exposition, but the kind there used cannot be successfully applied at sea under the present methods of using it."

Professor H. B. Gale.—"I have been greatly interested in the paper before us. It states some results which are certainly very surprising. If they can be well substantiated, the author has made one of the greatest discoveries of the age.

I have followed very closely the published accounts of experiments made on fuel, particularly liquid fuels, and have witnessed some experiments with oil, but have never seen or heard of any results approaching anywhere near to those reported in this paper. I think if the author expects the world to accept such wonderful results as six times the evaporative duty of coal, as reliable, that he should give more details as to the methods of the particular experiments where he has obtained such results. I know from experience

that it is very easy in making tests of the evaporative qualities of fuel to be led into serious errors from side causes.

It has been known for some time that a certain heating effect is sometimes produced by the combination of nitrogen in the manner described. Some years ago I listened to a paper at the Academy of Science in St. Louis, on this subject. The result of the experiments then reported was that the amount of heat obtained from the nitrogen was extremely small, and practically of no account.

Now, if it is possible to increase the effect of this element to such an enormous extent by the use of the particular furnace and fuel described by Admiral Selwyn, it is certainly something worthy of very profound and careful investigation. But I must confess that the paper has failed to convince me that this is possible. The furnace does not differ very essentially from some other furnaces which have been used in a similar way for burning oil fuel, and no such effect has been produced. Twice the effect of coal has been considered about the maximum that could be obtained.

Again, if compounds of nitrogen were formed in appreciable quantity in the case described, we should expect they would have some effect upon the metal of the boiler; and if nitrogen were consumed to the extent claimed, we should have in the analysis of the gases the evidence of that, and the proportion of nitrogen which was burned. From the analysis given I did not see that there was any evidence of such action, but rather the contrary. It is possible that the author has the results of an analysis which shows the combustion of nitrogen, and the amount. If he has such it would be very interesting to know it. I am not sure whether the calorific effect of a pound of nitrogen burned in this way is known to chemists, but as we have some chemists here with us this evening, I should be pleased to hear from them on this point."

MR. WAGONER.—"I have looked into this matter of fuels, both solid and liquid, several times, and I think the calorific values that are usually given may be accepted as correct. Beginning with green wood, whose value is about 4,000 heat units per pound; dry wood may be taken at 6,000; coal, such as comes to San Francisco, ranges from 10,000 to 14,000 units; coke, 12,000 to 14,000; tarry refuse oil from the refinery, 16,000; and crude oil, California, 18,000 units. These figures are the practical results of tests made under boilers by me at various times and places, and they are sufficiently near correct to enable the engineer to make a choice of fuel.

Concerning the remarkable results claimed in the paper read this evening, I do not think anyone well informed would admit the possibility of burning nitrogen in the manner claimed; therefore, whatever heating effect was obtained by the experimenter was that due to the formation of CO_2 and CO, and the analysis of waste gases showed such was the case.

One fallacy which is quite common, deserves mention, *i. e.*, the burning of water as fuel. The proponents forget that it takes as many heat units to dissociate steam as can be gained by the recombination of its elements, and with any other combination of said elements there would be a loss of heat."

MR. STUT.—"A few years ago I read a number of articles on this question. I think Prince Henry of Prussia instigated an investigation of the subject of liquid fuel, to ascertain the possible economy for the nation in the use of this fuel on torpedo boats. He noted what had been accomplished in England and other countries. If I remember correctly, the results of his investigations were about as Mr. Dickie stated, that the evaporative effect of liquid fuel, as used on the Black Sea, was about 11 to 12 pounds of water to a pound of oil; while the coal would be 7 or 8 pounds of water to a pound of coal. Unless the amount of this fuel is very large, and can be obtained at many different places on the globe, I do not see how much use can be made of it. Admiral Selwyn probably knows much more than I do as to the quantity that can be supplied.

I was employed by Mr. Dickie some years ago, and we made a little investigation and some tests of liquid fuel, and I know that we were not favorably impressed with it. I think we found it cheaper to burn coal. Is not that so, Mr. Dickie?"

MR. DICKIE.—"Yes, although the very high price of that fuel, delivered here, does not admit of its comparison with its use in other places where it would be cheaper. This fuel would have to be delivered at 75 cents per barrel to equal coal at $5.75 per ton."

PROFESSOR REULEAUX.—"I have learned from Russian engineers that the use of liquid fuel in Russia is about the same in expense as coal or wood; that in Moscow, for instance, it is fully as cheap to use oil, but that this is not the case in St. Petersburg.

I am afraid that Admiral Selwyn has not given us as complete an explanation as he may be able to give, as to the manner in which he arrives at such great results as the evaporation of forty-eight pounds of water from a pound of oil. Perhaps he will explain further, so that we may understand it better."

MR. W. G. CURTIS.—"In regard to the use of oil on the *Solano* and other ferry boats of the Bay, several years ago, I am not prepared to state the facts. We used a residual oil that cost $1.40 a barrel, and as near as I can remember, this price would about equal ordinary coal at $6.00 a ton. The matter, however, is not fresh in my mind."

ADMIRAL SELWYN.—"Mr. President, I think my answer must be a general one to the objections. First of all, gentlemen, I may say that if I had not had everyone of these objections before me for the last six and twenty years, I would not be here to talk to you to-day.

Secondly, there has been the most careful and skilled observation of every trial I have made by both civil and naval engineers. Everything was watched to see that there was no possibility of error in the measurements, the water was measured into the tanks, and out again to find what had evaporated, and thus the process was subjected to every test known to engineering. Therefore there is no doubt or question about what I am saying.

In the first place, as to the *supply* of fluid fuel, for that is really the most fatal objection, if it be not obtainable. I think you all know that the coast of South America has oil that is constantly running into the sea. My friends Treadwell and Noble have twenty mills there, and can send you just as much oil of any quality you choose to ask for.

Next, in speaking of our supplies, we have inexhaustible oil works. The shale of England is ten miles wide, and six hundred and fifty feet deep wherever we have gone to the bottom, extending across to Germany and Russia, and that will furnish more oil than we can use if the world lasts another thousand years.

I am not here to tell you of a new thing, but of a thing which I have studied, and in which I have been a leader for the last twenty years. The Germans, Italians, and Russians, have made inquiries about it from me, and came and studied in my boiler room at London. If they do not get the effects I have produced and vouch for, it is not my fault. If they will follow what I have given they will find that what I have said is borne out by the facts.

In regard to the use of oil on the San Francisco ferry boats, some were successful experiments, and others were not so. Considering that these experiments were made in the same locality, did one set of engineers do wrong and the others do right? We must presume so. Fifty-five per cent. economy was worth considering,

hough this is very little, and much less than I got when I started my work in 1867. There are gentlemen who have come to me and examined my work, and have gone away again and tried to imitate it without asking me about it; they were not willing to be instructed, and their labors stopped there.

I think you will find that in Germany they have followed the old ways in using this fuel. In Russia they are burning it against all the laws of combustion, in a boiler surrounded with water. I am in communication with a gentleman there, who keeps me informed of the methods employed; they are still very far behind in it. But if they get twelve pounds of water evaporated from one pound of oil, the subject is worthy of discussion."

MR. VON GELDERN.—"It is unfortunate that the author is unprepared to fortify the statements he has made, with data obtained from direct experiments. As long as we are left without actual figures, we cannot be expected to consider a subject for which such extraordinary results are claimed. An enthusiastic author must be prepared to submit more than generalities, if he would expect a detailed discussion of the subject he has chosen to present before a technical society.

In the present state of the fluid fuel question, our worthy guest has not been without his co-laborers, and all data heretofore available have not led to the sanguine conclusions drawn by him this evening."

REGULAR MEETING. SEPTEMBER 1, 1893.

PROCEEDINGS.

MINUTES.

The meeting was called to order at 8:30 P. M. by President C. E. Grunsky.

The minutes of the last regular meeting were read and approved.

Mr. R. J. Rolfson, M. E., applied for membership in the Society; proposed by H. C. Behr, Geo. F. Schild and Adolph Lietz.

As honorary guest of the evening, Geheimrat Professor Reuleaux, of Berlin, one of the eminent mechanical engineers of the day, was

welcomed by the President and asked upon the platform. He responded to the invitation and expressed his appreciation.

Admiral Selwyn delivered an address before the Society on the "Existing State of the Fuid Fuel Question," which was discussed at length by Professor Reuleaux, Messrs. Dickie, Gale, Stut, Wagoner, and others.

Mr. R. J. Rolfson exhibited and explained an improved friction dynamometer, connected with an automatic computing device, whereby the horse power of a prime motor is read off directly without any calculation. A discussion of this subject was held over for a subsequent meeting.

The following resolution was read and accepted:

IN MEMORIAM.

P. J. Flynn was born in Tralee, County Kerry, Ireland, in the year 1838. His early education was that ordinarily received, and purely rudimentary. He soon, however, developed a fondness for mathematics, and his inclinations in the choice of a vocation were towards the engineering profession. His surroundings and the locality in which he lived afforded little encouragement to his ambition. His resolve as to his vocation in life was soon formed, however, and at the age of fifteen he passed in a competitive examination at Addiscombe College, England, for a position in the Public Works Department of the Indian Service.

Arriving in India, Flynn was sent to the Roorkee Engineering College, where he spent six months in preparation for special work in Indian engineering. His rise as an engineer in the Indian service was rapid. Ten years service found him an executive engineer in the Public Works Department of the Punjaub. After remaining in India about eleven years he came to the United States and settled in San Francisco. Here Mr. Flynn remained for some time practicing his profession, when, thinking that the southern portion of California offered a better opportunity for the practice of hydraulic engineering, he removed to Los Angeles, where he established his permanent residence, devoting his entire time, until the day of his death, to his profession, and literary work connected therewith.

Mr. Flynn died at Los Angeles, California, on June 1st, 1893. He left surviving him a brother, John Flynn, residing at Sligo, Ireland, and a sister, Ellen Flynn O'Neil, residing at Brooklyn, New York. The deceased was the author of several works and pamphlets on engineering subjects. At the time of his death he was a member of the Technical Society of the Pacific Coast, of the Institute of Engineers of England, of the American Society of Civil Engineers, and of the American Society of Irrigation Engineers.

An instance of the unbounded esteem and regard in which his

brother members of the profession held him was exemplified to a marked degree by the character of the reception accorded to his recent work, published in San Francisco, entitled "Irrigation Canals and other Irrigation Works."

No one had a greater love for his profession, or more keenly felt and appreciated its responsibilities, or was more sensitive or alive to its duties than P. J. Flynn. As a man he was generous, manly, fair minded, fearless, conscientious, honest, and of sterling integrity, and always in search of the truth. As an engineer he was capable, painstaking, studious, and thoroughly wrapped up in the science of engineering. Although often solicited to lend his name to doubtful schemes, never did he yield to temptation, and the indorsement of an irrigation project by Mr. Flynn meant that it was both feasible and honest.

His profession was his love, and he did not follow it for the mere sordid desire of gathering worldly treasure, but his life was dedicated to it as a devotee of science, always inspired with the high-minded ambition to direct the forces of nature for the benefit and advantage of man.

His genius for work, his good judgment and the result of his labors have merited him the praise of the engineering profession.

Expressive of our sympathy and our respect for him, and our regard for his work, therefore:

Be it Resolved, that in the death of P. J. Flynn, the Society has sustained the loss of an honorable and distinguished member; the profession the irreparable loss of an able and industrious engineer; and the community a man whose attainments, sterling probity, patient industry, high talents, generous nature and amiable disposition endeared him to all appreciative of these qualities.

Resolved, that in this hour of bereavement we tender our deepest sympathy to the brother and sister of the deceased, and in token of respect and condolence we direct that a copy of this Memorial and these Resolutions, be transmitted to his surviving brother and sister, and that a copy thereof be spread on the minutes.

FRED. EATON,
BURR BASSELL,
V. J. ROWAN,
Committee.

Adjourned.

OTTO VON GELDERN, *Sec'y.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME X. No. 9.)

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COUNTRY ROAD CONSTRUCTION.

NOTES COMPILED AND PREPARED FOR THE STATE ROAD CONVENTION OF CALIFORNIA.

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INTRODUCTION.

By request of the Committee on Promotion, and appointed by the Technical Society of the Pacific Coast, we compiled and prepared the following notes. They were collated from Nessenius, a leading European authority on road building, with such omissions and additions as seemed to be justified and called for by the necessities in the present case.

For that reason we have not mentioned the Telford system, for instance, but have introduced a new chapter on dirt roads, believing that macadamized and gravel roads are best adapted in point of economy for our more important country roads, and that improved and well kept dirt roads will constitute in California the forerunners of better roads for some time to come.

In the same spirit we have replaced other parts of the original work by matter of more immediate utility.

MATERIALS EMPLOYED IN THE CONSTRUCTION OF GOOD ROADS.

The most reliable method of testing the fitness of paving materials is by means of experimental strips of pavement built into level sections of existing roadways. The wear of road coverings for one and the same material may be taken as proportional to the amoun of passing travel. Since the above method for testing the fitness of paving materials requires years of observations, the testing of paving materials in laboratories cannot be dispensed with.

Laboratory returns should state:

1. The petrographical name and geological occurrence of the sample.
2. Present use of sample.
3. Specific gravity of sample.
4. Absorptive properties of sample for moisture and water.
5. Weathering properties of sample.
6. Resistance to crushing on eighteen equally-sized preferably cubical specimens, of which three were crushed on the bed, and three on the edge in each of the following three conditions, namely:

a. Dry.

b. Water soaked.

c. Dried after having undergone twenty-five times a freezing and thawing process in a water-soaked state.

7. Wear and tear as deduced from the result of revolving the sample, previously reduced to road metal and then washed, in Deval's drums or "rattlers."

The establishment and liberal support of a State laboratory for testing road-building materials is herewith earnestly recommended.

A discussion of the results obtained on experimental paving strips, and in the laboratory, led to the following conclusions as to the wear and tear of road covering:

One cubic yard of basalt having a resistance to crushing of 24,040 pounds per square inch is equal to —

1.16	cubic	yards	of	Basalt	.....	with	crushing	strength	of	21,615	lbs.	per sq. in.
1.34	"	"	"	"	.....	"	"	"		19,200	"	" " "
1.70	"	"	"	"	.....	"	"	"		16,780	"	" " "
2.15	"	"	"	Graywake	.	"	"	"		14,370	"	" " "
3.00	"	"	"	Coral Limestone		"	"	"		11,750	"	" " "
3.80	"	"	"	"		"	"	"		10,810	"	" " "
5.80	"	"	"	Triassic Limestone		"	"	"		9,670	"	" " "
7-8	"	"	"	Sandstone		"	"	"		8,390	"	" " "
9-11	"	"	"	Cretaceous Limestone		"	"	"		7,260	"	" " "

With broken stone pavements a high resistance to breaking of the material is of the utmost importance, because the wear on such roads is greatly due to crushing. In moist and damp districts stones producing much dust should not be employed.

There is no lack of building stones in California. We have granites, syenites, diorites or green stones, porphyries, lavas, including basalts, triassic lime stones, and in some places hard slates and tough sand stones little distinguishable from the more ancient strata; nearly all of these give good road metal. In addition, cobble stones, gravel and sand abound in the creek beds and the upper reaches of the rivers.

VEHICLES.

Size of Wheels.

The construction of the vehicle is not only of the greatest influence upon the reduction of traction resistance, but it also affects the duration of the road covering.

Umpfenbach recommends the following wheel diameters for vehicles frequenting good roads:

1. For two-wheeled freight carts 5 feet 3 inches to 5 feet 9 inches.
2. For four-wheeled freight wagons, front wheels 3 feet 1 inch, hind wheels 3 feet 9 inches to 4 feet 2 inches.

These diameters should be increased from 6 to 12 inches for traffic on bad roads.

Width of Tires.

To prevent both the crushing of the road-metal by excessive wheel-pressure, and the destruction of the road-topping by ruts, there exist in nearly all civilized countries laws prescribing the proportion of gross-weight on wheel to tire-width.

It is proper here to remark that in more recent times the views as to the utility of very broad tires have somewhat changed, it being generally admitted now-a-days that outside of a certain tire-width a uniform transmission of pressure does not take place. The French Commission, presided over by Morin and Dupuit, recommends as maximum width of tire 4¾ inches, and as minimum width 2⅜ inches. Still, without any additional detriment to the road, larger wheels with the same width of tire may be more freighted than smaller wheels. Again the velocity and construction of the vehicle should be considered. The French Commission stated that a spring wagon at trotting speed does not wear a road more than a wagon without springs at walking speed.

In Hanover the width of wheel-tires for four-wheeled freight wagons is laid down by law as follows:

When laden with 0.8 tons to 2 tons.....2-inch
" " " 2 tons to 3 tons.....$2\frac{3}{4}$-inch
" " " 3 tons to 5 tons.....$4\frac{3}{8}$-inch
" " " more than 5 tons.....6-inch

For two-wheeled freight cars one half of these weights is permissible. The transportation of freights exceeding 7 tons, and of machinery of more than 10 tons in weight, is only permitted under certain conditions, which include the obligations to repair all damages done to the roadway, and to attend to all required re-enforcing of the bridges to be passed, etc. The tires should be neither concave nor convex.

This law was very unpopular in Hanover. On that account a new bill was lately introduced making the width of tires dependent upon the number of draught horses hitched to the freight wagon. Such a law is in operation in Bavaria. It reads as follows:

Minimum width of wheel tires of 2-wheeled carts, with 2 horses, 4.13 in.
" " " " " " 2-wheeled " " 4 " 6.18 in.
" " " " " " 4-wheeled wagons " 2 " 2.60 in.
" " " " " " 4-wheeled " " 3 to 4 " 4.13 in.
" " " " " " 4-wheeled " " 5 to 8 " 6.18 in.

Since over three-fourths of our roadways in California are dirt roads, which, even when well compacted, are readily destroyed by knife-like tires, it is all important that the law regulating the width of wheel tires be strictly enforced at once. There is certainly no use of spending money on roadways without entirely doing away with all narrow-tired vehicles.

But since the sudden and unconditional execution of the wheel-tire law is looked upon in many quarters as an act of hardship to the community, it has been proposed at the Convention, and we warmly second the proposition, as an initiatory step to making and preserving good roadways, that the different counties buy up and destroy all existing narrow-tired vehicles, insisting at the same time upon the exclusive introduction and employment of vehicles provided with wheel tires of approved width in future.

LOCATION OF COUNTRY ROADS.

While before the era of railways, the general tendency in road building abroad was to construct long roads in practically straight lines from one commercial center to the other, and to provide these

roads of great width with very substantial pavements for the accommodation of heavy freight wagons ; now-a-days it is more the aim to build narrower and lighter, and therefore cheaper roads, which, following the existing lines of travel as far as possible, open a better communication either from place to place, or, whilst touching as many intermediate points as practicable, lead the traffic to towns or railway stations.

"Location" includes all operations required to fix the alignment and elevation. Its aim is to reduce the total cost of conveyance by suitable construction and maintenance of roadways. Only those roads which satisfy this requirement are located economically correct.

THE GRADES OF ROADWAYS.

In order to insure a dry condition of roadways, it has been customary to build them somewhat higher than the land over which they pass; the necessary material for that purpose is obtained by an increase in the cross-section of the side ditches. It is requisite that the sub-grade of the roadway lie above the mean water level of the side ditches, so that a good foundation for the topping is assured.

In determining the proper grade of a highway it must be observed that the cuts should equalize the fills as nearly as possible, wherein the fact is to be considered that the material in a fill, though it be tamped, will not, for some time, pack as closely as in the original excavation or borrow pit. The excess depends upon the nature of the soil and the height of the fill, and varies considerably ; the mean may be taken at 5 per cent.

The opinion has been expressed that an undulating profile of a highway is of some advantage, for the reason that the alternating increase and decrease of the tractive force required will be less tiring to the horses. This view is obsolete. It is now assumed that horses will tire less on a horizontal than on an undulating stretch of road of the same length. Especially in the ascent of a hill it should be the problem never to lose an elevation that has once been gained, in order to reduce the required amount of mechanical work to the lowest minimum, unless it should prove that in carrying out this principle excessive amounts of earth work would be required. A loss of elevation should be avoided as much as possible.

Another reason given for the adoption of an undulating profile is that a better drainage is effected there than upon a horizontal plane. Sganzin went so far as to advocate alternating grades of at least

$1\frac{1}{2}$%. Wherever the topography does not in itself indicate an undulating profile it is certainly objectionable to construct one artificially. The side ditches, however, should be made with alternating rises and falls, so that they may lead the road drainage to the nearest main lateral drains.

THE GREATEST ADMISSIBLE AND CUSTOMARY GRADES.

The maximum admissible grades in highway construction are usually prescribed by legal regulations in most countries.

In Prussia the following standards are laid down :

a. In mountainous country 1 in 20, (5 per cent.)

b. In hilly country 1 in 25, (4 per cent.)

c. In level country, 1 in 40, ($2\frac{1}{2}$ per cent.)

Greater demands are made in Hanover. The technical regulations of 1860 call for the following grades, corresponding to *a*, *b* and *c*; 1 in 24, 1 in 30, and 1 in 40.

In Baden the maximum grades are :

Main highways with large traffic, 5 per cent.

Secondary roadways, 6 per cent.

Mountain roads that do not belong to the class of main highways, 8 per cent.

On curves in highways, 2 per cent.

In Brunswick the roadways in the Harz Mountains have a maximum grade of 1 in 18, in the hilly country 1 in 25, and on the plains 1 in $33\frac{1}{3}$.

Schleswig-Holstein allows grades of 1 in 24 (usually) on main highways, and 1 in 18 on secondary roads.

The old highways of Norway were very steep. Recent regulations prescribe a grade of 1 in 20 for main, and 1 in 15 for secondary roads.

If the tractive power of the horse is considered, and it is desired to avoid additional draught for a certain maximum load, then the highest permissible grade for that load should not be exceeded.

A certain expression has been made use of which shows the relation of the tractive force to the weight of the load. It is $K = \mu Q + (G + Q) \tan. \alpha$, in which K represents the mean tractive power of the horse, taken at $\frac{1}{3}$ of its weight, equal to 165 pounds ; Q the load, including the weight of the wagon ; G the mean weight of the horse, $165 \times 5 = 825$ pounds ; α is the angle of inclination, and μ the coefficient of resistance to road traction.

We shall refer to this formula again later on, where its derivation will be more fully explained. Q the load in the above expression, is equal to:

$$\frac{K - G \tan. \alpha}{\mu + \tan. \alpha}$$

and this form has been utilized for the computation of the following table, showing the load (with vehicle) that the average horse, exerting an average tractive force, can pull up a continuous incline having various grades and different coefficients of resistance, without requiring reinforcement at any time.

While the above formula holds good for all inclinations shown in the table, it must be stated that it is no longer applicable for excessive grades, for the tractive force in reality diminishes so rapidly that at an angle of 30 degrees it becomes zero.

Grade	Values μ					Grade	Values μ				
tan. α	$\frac{1}{50}$	$\frac{1}{30}$	$\frac{1}{20}$	$\frac{1}{10}$	$\frac{1}{5}$	tan. α	$\frac{1}{50}$	$\frac{1}{30}$	$\frac{1}{20}$	$\frac{1}{10}$	$\frac{1}{5}$
	Load Q in Pounds.						Load Q in Pounds.				
0.000	8250	4950	3300	1650	825	0.022	3497	2654	2040	1204	661
0.002	7425	4627	3141	1601	808	0.025	3208	2476	1925	1155	642
0.004	6737	4335	2994	1555	793	0.028	2956	2315	1819	1109	623
0.008	5657	3835	2731	1467	761	0.033	2599	2078	1660	1036	591
0.010	5225	3620	2612	1425	747	0.040	2200	1800	1467	943	550
0.012	4847	3424	2502	1385	732	0.050	1764	1483	1238	825	495
0.016	4217	3079	2300	1309	703	0.066	1285	1113	953	666	415
0.020	3713	2786	2121	1237	675	0.100	687	619	550	413	275

It is readily seen how very detrimental ascending grades are to the traffic, and how very considerable the required amount of tractive force becomes to overcome them. On a well-paved roadway having a coefficient of resistance of $\frac{1}{50}$ it is necessary to expend nearly five times as much tractive power to move a load on an inclination of 5 in 100 feet than would be required on a level.

It can be theoretically demonstrated that the tangent of the angle of inclination should not be greater than the coefficient of

tractional resistance, and according to this deduction it is evident that the smoother the road surface the easier should be the grade.

For the allowable maximum grade, Bockelberg proposes the following expression :

$$2\,\mu\,Q = \mu\,Q + (G + Q)\ \text{tan.}\ \alpha$$

In this formula, the letters denote certain values, as already explained.

In the consideration of this subject we shall assume the mean tractive power of a horse K at 165 pounds, which enables the animal to move on a level plane a load Q equal to its tractive pull divided by the coefficient of resistance, that is,

$$Q = \frac{K}{\mu}\ \text{or, in the average horse,}\ \frac{165}{\mu}\ \text{pounds.}$$

On macadamized roads having a coefficient of $\frac{1}{30}$, a horse will pull without over-exertion, $Q = 165 \div \frac{1}{30} = 4{,}950$ pounds.

The maximum allowable grade depends upon the additional effort that a horse is able to exert above its mean tractive pull, and it is generally conceded that on grades of moderate length, not over 2,300 feet, it may exert twice the amount of the adopted mean. Now since $\mu\,Q$ expresses the mean tractive force, we have $2\,\mu\,Q$ for the maximum pull, which must equal the weight of the load, wagon and horse, corrected for the grade, and the character of road topping, or $2\,\mu\,Q = \mu\,Q\ \text{cos.}\ \alpha + (Q + G)\ \text{sin.}\ \alpha$

We may simplify this expression somewhat by dropping cos. α from the first member, because on inclinations up to 1 in 10 it remains nearly unity ; and in the second member we may change the term sin. α into tan. α, for the reason that their difference is too small to affect the result, and the tangent has the advantage of expressing in a more direct manner the amount of the grade. This reduces the formula down to $2\,\mu\,Q = \mu\,Q + (Q + G)\ \text{tan.}\ \alpha$.

In the further consideration of this subject, we may omit the weight of the horse altogether, which is perfectly admissible in grades of moderate length, and we have

$$2\,\mu\,Q = \mu\,Q + Q\ \text{tan.}\ \alpha,\ \text{which is}\ \mu = \text{tan.}\ \alpha.$$

This means that the tangent of the permissible inclination—which in a reach of moderate length does not require an additional horse to overcome it—is equal to the coefficient of resistance to traction. On a well-paved road, therefore, where $\mu = \frac{1}{30}$, rises greater than 1 in 50 ought not to occur, while on poor earth roads a grade of 1 in 10 is not excessive. The coefficient of resistance to traction has been

established for roadways of different character and material by the best authorities, as follows:

For the best block paved roads ..... $\frac{1}{75}$
" the best macadamized roads ..... $\frac{1}{50}$
" well macadamized roads ..... $\frac{1}{30}$
" gravel roads and ordinary macadamized roads ..... $\frac{1}{25}$
" smooth, solid and dry earth roads ..... $\frac{1}{20}$
" poor earth roads ..... $\frac{1}{10}$
" very poor earth roads ..... $\frac{1}{5}$

In the establishment of his grade the engineer is justified in assuming that the better the condition of the road, the lighter must be the grade, and that the expression $\mu = \tan. \alpha$ prescribes for him a measure that is perfectly applicable.

The same theoretical limit has been obtained for the descent, assuming that the vehicle should be free from all tendency to roll down by gravity, and that a restraining or holding back of the span should be entirely excluded from the consideration of the subject. The necessity becomes apparent then of considering, first of all, the road topping, upon which the tractional resistance depends, before determining the grades in the project for a new highway.

Another point of great practical importance in the determination of the grades is the velocity with which the traffic is to be carried on. It is assumed by Bockelberg that a well equipped coach, in ascending a roadway having a grade of 1 in 22, cannot accomplish long reaches with the horses at a trotting gait. That is, such a grade is too steep for anything above a fast walk; on inclinations of 1 in 30 to 1 in 33 the trot may be kept up for a longer time, but for a continuous run at this gait the grade should not exceed 1 in 36 to 1 in 40.

In descending at such a speed without brakes, a grade of 1 in 16 is considered as dangerous; 1 in 20 as not advisable; 1 in 22 necessitates a careful management of the animals and moderation of the speed; 1 in 24 on well-paved roadways requires that the horses be held firmly in check; and only at 1 in 36, and under conditions at 1 in 40 to 1 in 45, is it safe to travel over long stretches at a trotting gait without the application of brakes.

It is readily seen that the adoption of the grade of a certain highway depends not only upon the presumable resistance to tractive force, and upon the load transported, but in a measure upon the contemplated velocity at which the transport shall be carried on. From what has preceded, however, it will be noticed

that a grade of 1 in 50 on well-paved roadways (corresponding to a coefficient of resistance to $\frac{1}{30}$) is not too steep for a continuous trotting gait under the standard load corresponding to that grade.

THE DETERMINATION OF THE MOST ADVANTAGEOUS GRADE.

Although the maximum permissible degree of inclination has been set down in the foregoing, it has not been decided as yet whether such grades are the most advantageous, or whether it would not be better to adopt a still smaller grade? In order to settle this question definitely it is proper to consider every element that affects the actual cost of transportation, and to aim at reducing this as much as possible.

The expenditures of moving a load upon a highway depend upon :

1. The angle of inclination α.
2. The coefficient of resistance to road traction μ.
3. The tractional force K, which draught animals are able to exert at a mean velocity c, during a mean working time t.
4. The law, according to which the tractional power of animals varies with the change in the mean velocity or working time.

In consideration of this factor Mascheck's formula has been used, which expresses the tractive force in this wise :

$$K_{,} = K\left(3 - 2\frac{v'}{c}\right)$$

In order to make this clear it is well to refer to a short theoretical consideration of this point. The work L of animal locomotors is, like all mechanical work, the product of a power $K_{,}$ (the tractive force), into the velocity v, and into a certain element of time Z, during which that power is exerted ; therefore $L = K_{,}\, v\, Z$. These three factors differ in every draught animal according to individual conditions, but they hold such a relation to each other that an increase in tractional force diminishes velocity and time ; an acceleration of the velocity reduces the force and time ; while a more extended duration of work will weaken the force and lower the velocity.

The following formula of Mascheck has been generally employed :

$$K_{,} = K\left(3 - \frac{v}{c} - \frac{Z}{t}\right)$$

In which :

K = a mean tractive force.

c = a mean velocity.

t = a mean working time.

It may be readily demonstrated that with these mean factors the maximum work performed is $L_{\max.} = K\,c\,t$.

K is usually taken at 165 pounds, $c = 3.6$ feet, $t = 8$ hours. Then the work done in one hour will equal 2,147,310 foot pounds.

If the value c, K and t, and with it the maximum day's work cannot be reached (if, for instance, a greater velocity be required), we must endeavor to obtain a relative maximum, which is tied to the condition $\frac{v}{c} = \frac{Z}{t}$

Introducing this value reduces Mascheck's formula to the expression :

$$K_{,} = K\left(3 - 2\,\frac{v}{c}\right) = K\left(3 - 2\,\frac{Z}{t}\right)$$

This formula furnishes results in harmony with practical experience as long as the values of K, c and t do not exceed the mean values beyond reasonable limits. The values of K, c and t depend entirely upon the condition of the horse, and must of necessity vary within wide limits. Bockelberg, for instance, assumes $c = 4$ feet ; Sganzin places the most advantageous velocity that an animal will assume, when it is neither held in nor urged on, as follows :

A heavy horse, 2.93 feet.

A lighter animal, 3.66 feet.

5. The weight of the unloaded wagon $Q_{,,}$ the mean of which has been taken at 1,320 pounds = 8 K.

6. The weight of the load $Q_{,,,}$.

7. The weight of the draught animal taken at 5 K = 825 pounds for one horse.

8. The monetary value of the daily work of the animal.

9. The probable costs of both the new roadway construction and the maintenance of the highway. Considering all these factors, a mathematical deduction has led to certain results that express the most advantageous grade, which it is not necessary to carry out in detail here. Launhardt, by a careful analysis in this line, and by assuming the following values : $\mu = \frac{1}{30}$; $Q_{,} = 1{,}320$ pounds, and $G = 825$ pounds, has arrived at the following conclusions :

Dependent upon the amount of traffic, and the cost of construction and maintenance of the highway, the most advantageous grade varies :

For mountainous country between ..... $\frac{1}{20}$ and $\frac{1}{30}$
" hilly country between ..... $\frac{1}{30}$ and $\frac{1}{40}$
" level country between ..... $\frac{1}{40}$ and $\frac{1}{50}$

and for an ordinary traffic on roads built at an average cost :

In mountainous country ..... 1 : 24
In hilly country ..... 1 : 36
In level country ..... 1 : 44

It will be noticed that these deductions give results somewhat smaller than those laid down by the road regulations of European countries, which were previously mentioned. In one item, in that of hilly country, however, is there shown any considerable deviation from practice, the others nearly agree with the results of theoretical deduction.

CROSS-SECTION OF COUNTRY ROAD.

The stone covering aims in the first place at the establishment of a hard, practically level surface which, on transporting freight, tends to reduce the resistance to tractive force, and thus to lessen the cost of freighting. The topping should also transfer the wheel pressure received from its small area of contact to a large surface of the substratum, and in addition, protect the latter against the direct influences of traffic and weather.

Alongside the paved road is often left an unpaved portion which is desirable for horseback riding, and the use of unshod draught animals, and if kept in repair will prove serviceable for lighter agricultural vehicles during the dry season. On steep grades the summer or dirt road portion, is much liked by teamsters, because it opposes greater resistance to descending vehicles.

In new countries such double roads offer great facilities for widening the pavement at a very reasonable outlay later on.

On macadamized roads without dirt-road portions, we usually find two earth banquettes or shoulders, intended for foot-passengers on one side, on the other for storing road metal. On both sides of the road ditches are frequently found.

The limits in width of artificial country roads lie between 16 and 50 feet; of the former width, about 12 feet — exceptionally 10 feet— are utilized for the macadamized part, and two feet, or three feet respectively, for the banquettes or shoulders. To these dimensions are to be added the widths of the ditches.

Bockelberg says desirable widths for the metaled part of roads are : with slight traffic, from 11 ft. 3 in. to 13 ft. 3 in.; with moder-

ate traffic, from 13 ft. 3 in. to 15 ft. 3 in.; with larger traffic, from 15 ft. 3 in. to 18 ft. 9 in.

The widths of French roads, as given by Sganzin, are as follows:

	Widths of footpaths or Dirt-Road Portion.	Widths of Metaled Roads.	Total Width.
Main roads	21 feet 9 inches	21 feet 9 inches	65 feet 3 inches.
Department roads	9 " 10 "	19 " 8 "	39 " 4 "
Principal county roads	6 " 6 "	19 " 8 "	32 " 8 "
Common roads	5 " 0 "	16 " 5 "	26 " 5 "

In Holland: width of metaled portion of road, 14 feet; width of raised banquettes, one on each side, including their sod revetment, twice 12 feet, total width, 38 feet. On roads of less importance these dimensions are reduced to 10 feet + twice 6 feet = 22 feet.

F. Collingwood, E. P. North, and J. J. Owen, say:

"We think the width of road metal or other covering should not be less than 16 feet, except where all traffic is very slow, where 12 feet may answer. This is a matter for the judgment of the engineer."

Very narrow roads are disadvantageous, because they wear badly. Since on them the draught animals prefer the middle of the road, ruts on the side and a hog's back in the middle are soon formed. Experience proves that, within the usual limits of road widths, the expenses for maintaining broad roads are less than for narrow roads, if both are subjected to the same amount of traffic.

The widths of our California country roads vary from 30 to 60 feet. The latter width is wasteful, because the largest sized agricultural vehicles known to the authors can safely pass each other, even on curves of 90 feet interior radius, on roads 40 feet wide. Thirty-five feet of roadway width is enough for a regular traffic of four ordinary vehicles. We, therefore, are in favor of limiting the width of our California country roadways in agricultural sections to 40 feet, which dimensions might be increased to 50 feet near large cities. Good roadways of from 16 to 35 feet in width should meet all just demands in non-agricultural districts.

To carry off the rain water as speedily as possible, and thus to prevent the soaking of the subsoil, a lateral fall or side slope is given to the road. Of course, this end would be better reached by steep than by gentle slopes; but it is to be remembered that steep side slopes render the traffic difficult, and on roads frozen slippery become seriously dangerous. Usually the middle of the road is rounded like an arch, while the sides form inclined planes.

Exceptions to this rule are found on well constructed mountain roads, where, in order to reduce the danger of vehicles sliding toward the precipitous valley side, the topping forms an inclined plane pitching toward the mountain; in which case the drainage from road and mountain slopes is conducted by pipes or cascade culverts under and across the roadway.

Since the shed of the surface water follows the line of greatest descent, which is composed of the longitudinal and lateral falls of the road, the side slope should be somewhat regulated by the gradient of the road; less side slope should be given on steeper road grades. Still, enough pitch must be allowed to prevent the rain water from running off nearly in the direction of the road, in which case it might cause the washing out of the topping. Umpfenbach observed on roads where these rules were violated, that on a grade of $\frac{1}{12}$ the surface was muddy, on grades from $\frac{1}{48}$ to $\frac{1}{36}$ clean, and that on grades of $\frac{1}{18}$ the roads began to deteriorate on account of the washing out of the binding gravel.

Nessenius gives the following table of suitable side slopes for macadamized and dirt roads of different grades.

Grade of Road.	Side Slope, Macadam Road.	Side Slope, Dirt Road.
0%	7%	5%
0% – 3½%	5½%	3½%
3½% and over	4%	1½%

CURVES.

The smallest radius of curvature allowable on roads, chiefly depends upon the maximum length of teams frequenting the road. Theoretically, taking the maximum length of team, viz., length of vehicle and its four-horse span equal to 49 feet, in order to retain said team on a macadamized or improved roadway-crown 12 feet wide, the minimum interior radius of curvature should be about 100 feet; 75 feet when 16 feet, and 66 feet interior radius when 18 feet wide.

In Saxony the permissible minimal radii are as follows: on principal roads, 82½ feet; on roads on which logs are transported, 100 feet; on ordinary country roads, 39½ feet.

In France on the Orleans roads the minimal radii are: on main roads and department roads, 100 feet, but generally 165 feet; on principal country roads, 49½ feet.

We would propose for our California country roads of 40 feet width, a minimum interior radius of curvature of 90 feet, and of 50 feet width a minimum interior radius of 81.0 feet.

FINAL LOCATION.

It would go outside of the proposed programme to enter here in a discussion of all the technical and financial points to be weighed when making the final choice between the different possible road routes to connect important points.

The general principles followed in railroad location hold good here also. Make the line as short as practically consistent with easy grades, gentle curves, good drainage, cheap supply of material and lightest work in building.

The engineer's report on the construction of a proposed new road should be accompanied by—

1. A general map on a scale of from $\frac{1}{20000}$ to $\frac{1}{200000}$.
2. A detailed map on a scale of from $\frac{1}{600}$ to $\frac{1}{3000}$.
3. A longitudinal section on a scale of the detailed map as to horizontal distances, and on a scale twenty-five times larger as to elevations, and figured with reference to established bench marks.
4. Cross sections where needed for a thorough understanding of the proposed improvements.
5. Designs of required culverts and bridges.

CONSTRUCTION OF NEW BROKEN STONE ROADS.

Fillings made with sandy soil usually receive slopes with inclinations of 2 base to 1 perpendicular, and when done with better soil, 1 on 1½. More gentle slopes are required where the roadbed is exposed to high waters or waves. Steep hill slopes that might cause a sliding of the fill, should be cut into steps before the roadway embankment is placed upon them. Excavations for foundations receive slopes somewhat steeper than 1 on 1½, consistent with the character of the soil; with sound rock, slopes of 1 on ½ are usual.

If on long slopes the velocity of the running storm water is greater than the nature of the soil will withstand, the slopes are terraced, that is, they are provided with horizontal offsets, benches or bermes. If the depth of the excavation does not exceed 8 feet, the slope usually has a berme at the height of the crown of the road. In deeper cuts the bermes should be vertically distant about 7 feet, beginning from the bottom of the ditch. More perfect drainage is attained by giving the benches a cobblestone gutter on the outer side to receive the surface water from the portion of the slope above them. These gutters discharge by means of paved drains into the ditches.

On swampy soil complete success in filling is assured by replacing the muck with sand. The same can be accomplished by dumping sand through an excavation in the sward, until the muck is forced aside and the sand has reached the solid ground below. In most cases, however, particularly in bogs of great depth, this method is too expensive for application.

If above the very soft ground there should lie a bearing stratum, then the roadbed might be constructed on it with very light peat. This filling should only be high enough to keep the rising ground water from reaching the subgrades. On both sides of such roads benches are left, often of considerable width. The side ditches outside of these should be made very broad and shallow, and have a free outlet.

DRAINAGE.

The drainage of fat, wet soil is effected by means of tiles. The circular tiles are best laid lengthwise to the track on each side of it, and not less than 18 inches below the subgrade. They have an average fall of about 1 in 100 ; minimum fall 1 in 1,000. At short intervals, say from 36 to 100 feet distant, are placed cross drains to discharge the water into the side ditches. These cross drains receive a greater fall, say up to 1 in 30. Generally 2½ to 3-inch pipes are sufficient. It is advantageous to bed these tiles in well-rammed brick fragments, and to cover them with road metal. Be certain that the tiles are correctly laid, and that nothing interferes with their free discharge.

SIDE DITCHES.

Side ditches are provided to dry the main body of the road, to drain off the rainwater, and to enclose the road. Ditches should be employed in connection with road fillings of less than 20 inches in height, and in all excavations. The ditch slopes should be at least 1 on 1½, exceptionally 1 on 1. The interior slopes of side ditches are, of necessity, flatter with roadways constructed and maintained with road machines, the maximum attainable dip of the scraping blade of the pattern in use limiting the steepness of the slope. Width of ditch bed at least 18 inches, depth of ditch from 20 to 40 inches. The water surface in ditch should not reach to subgrade, but remain at least 12 inches below the crown of the road. The longitudinal fall of the ditch follows the configuration of the general topography, that is, the natural drainage. When the

latter is to be aided artificially, grades of not less than 1 in 800, or still better 1 in 500, will usually answer.

In absorbing soil less fall is sufficient, and in certain cases even level ditches are permissible. The slopes of the ditches must be protected where the grade is considerable. This can be accomplished by sod revetments, rip-rapping, or paving.

In mountainous countries, or deep cuts, paved gutters of from 30 to 60 inches in width are used in place of ditches; they are also preferable in all narrow passages. Grade of paved cobble stone gutters should be from 1 in 100 to 1 in 150.

CULVERTS, CANALS, BRIDGES.

The drainage from the roads ought to discharge speedily into existing creeks and rivers. To this end it is often necessary to conduct the water across the road-bed. Box-culverts used for this purpose, should have not less than 20″ × 20″ cross-section, and if pipes are used, they should have a mininum diameter of 10 inches. In districts suffering little from severe frosts the top of such drains may be situated 24 inches below the crown, otherwise 30 inches.

In preparing designs for new country bridges the weight of a ten ton steam road roller should be considered.

CHOICE OF STONE ROAD COVERING.

When treating the question in what manner a stone road should be constructed, the existance or absence of suitable road building materials, the first cost of pavement and charges for maintenance should primarily be considered. If that does not decide the choice, the following observations will assist in solving the problem.

Stone paved roads owe their solidity and durability to the larger sized stones that form the covering, which toppings are particularly suitable for heavy and important traffic. Stone paved roads are preferable in towns and villages, for the reason that they cause little dust and mud. They are also advantageous in sections which are very distant from the place of stone supply, and where on that account the cost of dressing the stones in the quarry is insignificant in comparison with the heavy freight charges, because in the construction and especially in the maintenance of a stone paved road, less material is required than for first class broken stone roads.

Although the first cost of stone paved roads is higher than that of another character, the light repairs necessitated by the former

make them rather cheaper in the end. The broken stone roads on which much surface wear and tear takes place, are more suitable for light, rapid transit than for heavy traffic. It is claimed that they keep better on unstable ground. But, certainly, in damp sections, as, for instance, in woods, and on very moist subsoil, broken stone coverings are not suitable, for when wet, they suffer particularly by the traffic; under such conditions, stone paved roads are preferable.

Again, the repair of broken stone roads is always annoying to the traffic. Broken stone roads require careful maintenance. When neglected they suffer to such a degree as to become useless in a comparatively short time. The cost of reconstructing spoiled broken stone roads nearly reaches that of the original construction. Hence, on inferior and distant roads, which lack the benefit of competent supervision and maintenance, cheap stone paved roads are preferable, for, even when badly maintained, they don't go to entire ruin, and under the most unfavorable circumstances always offer suitable material for rebuilding.

The advantages of broken stone roads are their comparatively low first cost. Again, they offer, when somewhat cared for, a smoother surface than the average stone pavements, for that reason they present less tractive resistance to wagon traffic, are preferred for passenger traffic and cause less noise.

VITRIFIED BRICK ROADS.

Vitrified brick roads are unsuitable for heavy traffic, on account of the small resistance the clinkers offer to crushing, but they answer very well for light traffic. By reason of the usual high price of vitrified brick, this kind of a road is only found where natural stones are wanting, or where their use becomes too expensive on account of freight charges. Again, since clinker roads require a thin sand covering for their protection against rapid wear, they are best suited in sheltered localities.

The chief reason for the increasing introduction of vitrified brick roads on foreign coasts lies in the local want of natural stones, which is felt more and more from year to year.

Clinker pavements were first used on an extensive scale in Holland, from where they were introduced into Prussia. There these roads give great satisfaction and appear to cost less than roads paved with imported stone.

TRANSVERSE CONTOURS OF STONE ROADS.

For narrow roads a basket line whose flattest part forms the crown of the road is suitable. For broad roads two gently inclined straight lines, rounded off by a short circular arc at the center of road, give a good form.

Nessenius states that gravel roads of 11½ feet width, having a flat arching of $\frac{1}{36}$ of road width as total rise, wore better in Hanover than similar roads having a transverse contour of two tangents joined by a short circular arc.

The curvature of broken stone roads must be all the greater, the poorer the road metal, for it is more difficult to cause the shed of the storm water from uneven and dirty roads than from smooth coverings. On level grades the total rise of $\frac{1}{29}$ road width is suitable for the average broken stone road with circular transverse contour, and of $\frac{1}{48}$ on grades exceeding 1 on 36.

With vitrified brick roads the total rise should not exceed $\frac{1}{40}$; $\frac{1}{60}$ being usually taken.

BROKEN STONE ROADS.

Material.

Hard and particularly tough stones are needed for such roads, because the consumption of road metal for maintenance would be unproportionally large if it were otherwise, as the wear of the pavement would then be due not to abrasion but crushing.

The selection of a superior material for broken stone roads is of greater importance than for block pavements, because a paving block, even if of very moderate hardness, will still offer sufficient resistance to the pressure of the wheels, owing to its large surface, while fragments of the same material forming the covering of macadamized roads would under the same circumstances be broken to pieces.

Rocks, which furnish road metal of cubic alform and granular texture, are preferable to brittle materials, which splinter under the hammer. Very brittle stones, like flint and certain recent limestones are entirely unsuitable for road coverings. Objectionable for broken stone coverings are also stones which form a sticky and tough mud, or wear to a sandy dust; while stones producing some cementing and hardening paste, which fills the voids between the fragments, are desirable.

Nessenius classifies the materials used in broken stone roads as follows:

Hard and binding stones: basalt, porphyry, granite, paleozoic limestones.

Hard and lean: gabbro, greenstone, syenite, hornblende rock, graywacke.

Less hard but well binding: triassic limestones.

Less hard and lean: variegated sandstones and other loose sandstones.

Breaking of the Stone.

The stone ought to be broken in cubical pieces of about equal size. Flat and splintery pieces are objectionable, because the strength of fragments diminishes the more they differ in form from cubes. The road metal should not be broken finer than is positively required, because the smaller the fragments the greater the wear and tear of the road-covering they form.

The road metal can be prepared by hand. In this case the laborers use for stone breaking, either short handled heavy hammers with which they break, in a sitting posture, the stone on a larger stone — the anvil; or long handled lighter hammers with which they strike in a standing posture. Each laborer is provided with gauge rings through which the broken stones must pass. The average amount of stone broken by a good stone breaker is according to Codrington as follows:

Hard silicious stones and igneous rocks, 1 to 1½ cubic yards per day; granite ½ cubic yard per day; river gravel and field stones, 3 to 4 cubic yards per day.

It is claimed that more work is done with the long handled striking hammers than with the short handled heavier hammers, but that the stones broken on the stone-anvils give more uniform and better road metal.

While stone breaking by machinery is a great deal cheaper, the road metal thus produced does not come up in quality to the hand broken one. Of course, the use of steam stone breakers is only justified where this machinery can be kept constantly at work, and where the cost of transportation from the quarries to the stone breakers is small. For extensive operations stone breakers are always employed, but the breaking of small quantities of rock furnished by insignificant, isolated qnarries is better done by hand.

Of the many steam stone breakers in use the following are the best known: Austin's, Blake's, Buchanan's, Farrel & Marsden's, Hoagland's, the National Machinery Co's, Young, Brennan's, the American Road Machine Co's, the Western Wheeled Scraper Co's.

A complete stone-crushing plant consists of an engine moving a breaker which crushes the stone; an elevator which raises the broken stone to the rotary screen; a rotary screen, which separates the broken stone into three sizes and deposits it in bins, which easily discharge into dump wagons. A rejection spout returns the imperfectly broken stone to the breaker to be recrushed.

The coarse stones may be brought from the quarry by wire rope tramways, and dumped into the chutes leading to the crusher.

BROKEN STONE FOUNDATIONS.

Their introduction is the result of the gradual development of Macadam's manner of road building.

The broken stone for the foundation layer should be, if harder material is used, 2 inches, and if softer road metal is employed, 3 inches in size. For the construction of this layer may be employed poorer material than for the topping, if by doing so a saving in money results.

The foundation layer should be rolled with light or unballasted rollers, and without binding material. The rolling is to continue until the stones begin to compact firmly, but not long enough to form a smooth surface. Where there is no danger of a loosening of the foundation layer by frost, the bottom layer may be made of gravel or smaller broken stone. The thickness of such layer is from 0.4 to 0.6 of the total thickness of stone-beds.

The broken stone for topping varies from 1½ to 2 inches in size, according to the merits of the material and the expected traffic. The thickness of the topping should not be less than 3 inches at the border, if foundation and topping are of the same material, otherwise, in the middle, 4 inches and on the sides 1½ to 2 inches. Lighter topping, while admissible with very hard, tough and expensive road metal, is not recommendable.

If the material for the foundation layer is of poor quality, and the superior metal for topping very dear, then it might be advisable, in case middling material is at hand, to use such for forming a middle layer, which is also to be rolled down several times. Foundation and topping layers are made of less thickness under this condition.

FURNACE-SLAG ROADS.

Recently furnace slag has been employed with great success in place of broken stone for road covering, the modus operandi in building such roads is the same as that just described for broken stone roads.

Since common slag is unsuitable for road making on account of its brittleness, it must be specially tempered for such purposes. To this end the slag is run off into pits, there covered with coal or slag hogging, and permitted to cool off slowly in order to become dense and granular upon solidifying. Such slag offers to breaking about the same resistance as basalt, with which it nearly competes as topping material.

QUANTITY OF MATERIAL.

From investigations we learn that closely-piled up quarry stones contain (depending upon their natural cleaving) from 54 to 66 per cent. solid rock, and from 46 to 34 per cent. voids. An additional increase in volume of such a pile happens on further breaking the quarry stone, which, Voiges says, amounts to 10 per cent. with Basalt, 15 per cent. with quartzites.

Generally we assume that loosely-dumped road-metal contains about 80 per cent. of the solid material held by the original quarry stone heaps. If we further assume that the construction of the broken-stone covering absorbs from 1.4 to 1.6 times its volume in road-metal we shall find that the quantity of piled-up quarry stones needed answers about $1\frac{1}{10}$ to $1\frac{3}{10}$ of the volume of the finished broken-stone road. Thus a road 15 feet wide, of an average thickness of 6 inches, requires, per running yard of road, one cubic yard of closely-piled up quarry stone.

A discussion of road statistics of twenty-eight counties shows that in an aggregate length of 14,310 miles of California country roadways there are only 116 miles of macadamized roads, or less than one per cent.

GRAVEL ROADS.

The thickness of the metaling ought to be increased by one-fourth, or, better still, by one-third, if gravel and coarse sand are the only road materials at hand. These roads can be built with a foundation layer of large gravel or cobbles, or of uniform and finer gravel. It is advisable to construct such roads in two layers, and to roll each of them by itself. The use of border stones is desirable with gravel roads, although it is often omitted. The characteristic difference between these roads and broken-stone roads lies in that gravel roads contain a road metal somewhat rounded off, which, on that account, cannot in itself form a well-compacted coherent cover.

A cementing material for filling the interstices is therefore needed, that is, something of the character of a binding material.

Such is usually found in the required quantity with pit gravel, but washed river gravel, which, when loosely dumped, contains from 40 to 45 per cent. of voids, needs an addition of sufficient loam. To secure a good mixture it is well to spread the loam uniformly over the gravel layer in situ, and to treat the whole with rakes or harrows. To assist toward a better breaking up of the loam, it is desirable to let it lie in the air for some time, and, if possible, to let frost act upon it.

The resistance of gravel roads depends upon the resistance of their binding material. During dry weather it is very pleasant to drive upon gravel roads, but during continued wet weather they begin to soften. Gravel roads always require careful maintenance to secure a speedy shedding of the storm water and to assure a filling in of eventually formed ruts. The construction of gravel roads is customary in districts in which gravel abounds and other stones are scarce. Gravel roads are particularly recommendable in localities in which little rain falls, or where only light traffic takes place during the summer and little of it during the winter season.

In a recorded aggregate length of 14,310 miles of California country roadways we find 2,287 miles of gravel roads, or about 16 per cent. of the total amount.

DIRT ROADS.

About 75½ per cent. of the country roads in California belong to this class. Their extraordinary widths necessitate particular care as to proper drainage, without which the loamy reaches of our roadways soon turn into quagmires during the rainy season. It is well to observe here that with wet or clayey roadways surface drainage alone is not sufficient. Without under-drainage the crown of such roadways will only dry by the slow process of evaporation, during which time the topping becomes more and more rutted by the passing traffic.

A sub-drain in such soils will not prove efficient for more than about 12 feet on each side. Hence two lines of longitudinal sub-drains are needed on those parts of our California country roads that pass through wet places, low-lying lands or clayey soils.

As said before, unglazed round tiles, about 3 inches in diameter, and, under certain conditions, jointed with loose collars are most suitable for sub-drains. The bottom of the tiles should be laid both to the proper grade and below the frost line, after which the tile trench is filled up to sub-grade with clean gravel, small field-

stones, road-metal or broken bricks. The cross drains are also made of unglazed tiles, with the exception of their outlet sections, which should consist of vitrified culvert pipes. Regular branch pipes should connect the longitudinal and cross tiles.

On level reaches the lateral roadway slopes for surface drainage should not be less than 1 on 24 ; and side ditches should be provided, if necessary, as previously indicated. Finally a rapid discharge of the side ditches, if required, through adjacent lands is of the utmost importance to roadway preservation.

Trees should not be allowed on the sides of dirt roads, because they impede the drying actions of the sun and wind. Again, their waterseeking roots are apt to creep into the drains and thus obstruct, if they do not prevent, the function of the tiles.

To economically build and repair our wide California dirt roads, modern earth-moving implements and machinery should be used. We mean grading ploughs, drag and wheel scrapers, harrows, road-levelers, road machines, Western elevating or "New Era" graders and wagon loaders, and improved dump wagons. Furthermore, road rollers, wind mills or pumps, water tanks and sprinkling carts should be provided.

In constructing new dirt roads, all stumps, brush, vegetable matter, rocks and boulders should be removed from the surface, and the resulting holes filled in with suitable material, carefully and thoroughly tamped or rolled, before the road embankment is commenced. No perishable material should be used in forming the permanent embankment.

Wherever the sub-grade soil is found unsuitable, it should be removed and replaced with good material, rolled to a bearing. The roadbed having been brought to the required grade and crown, should be rolled several times to compact the surface. All inequalities discovered during the rolling should be leveled up and re-rolled.

On the prepared sub-grade, the earth should be spread, harrowed if necessary, and then rolled to a bearing by passing the unballasted road roller a number of times over every portion of the surface of the section.

In level countries and with narrow roads, enough material may be excavated to raise the roadway above the sub-grade, in forming the side ditches by means of road machines. If not, the required earth should be obtained by widening the side excavations, or from cuttings on the line of the new roadway, or from borrow pits close by ; elevating graders and modern dumping wagons being preferably

used for this purpose. When the earth is brought up to the final height, it is again harrowed; then trimmed by means of road levelers or road machines, and ultimately rolled to a solid and smooth surface with road rollers, gradually increased in weight by the addition of ballast.

No filling should be brought up in layers exceeding 9 inches in depth. During the rolling, sprinkling should be attended to wherever the character of the soil requires such aid.

The cross-section of the roadway must be maintained during the last rolling stage by the addition of earth as needed.

On clay soils, a layer of sand, gravel or ashes spread on the roadway will prevent the sticking of the clay to the roller.

As previously explained, the finishing touches to the road surface should be given by the heaviest rollers at hand.

Before the earth road is opened to the traffic, the side ditches should be cleaned and left with the drain tiling in good working order.

Earth-moving implements and road machines are manufactured by the Western Wheeled Scraper Co.; The F. Austin Manufacturing Co.; The American Road Machine Co.; Montgomery, Ward & Co.; San Jose Foundry, etc.

The names of firms building road rollers are elsewhere given.

Dirt-roads can be improved temporarily, when wet, by layers of brush closely packed and covered with pit gravel.

Since wet sand topping offers less tractive resistance than dry sand, sandy roads should not be drained. Such roads may be improved by a 6-inch layer of good clay. A topping of dry reed or marsh grass, etc. improves the surface of sandy roads, and maintains this condition for some time. About 4.7 per cent. of roadways in California are sand roads.

On clayey roadways, a layer of sand acts beneficially, and all dirt-roads are greatly improved by road metal, furnace slag or gravel coatings.

Dirt-roads are readily repaired by a judicious use of road machines and road rollers.

Ploughs and scoop scrapers should not be used for this purpose.

These repairs should be attended to particularly in the spring of the year, and whenever the roadway becomes rutted subsequently. It is best to commence by lightly scraping at the side ditches, and operating towards the middle of the roadway; following the work up and finishing it with the heaviest road rollers. Holes which are not

thusly filled, should be leveled up with gravel, hogging or other suitable material, and then, well compacted with rollers. If possible, these repairs should be executed during damp weather, or at least, after a good road sprinkling.

The average cost of the better California country road is $800 per mile; the price varying between $400 and $2,000.

TEMPORARY ROADS.

On swampy ground where the expedients mentioned above are not sufficient or applicable, a suitable log or corduroy road may answer. To this end notched cross logs are placed upon good and solid stringers that are laid along the road bed laterally. The former are again secured near each end by a longitudinal tie, covering them, and tree-nailed down. The cross logs are covered with brush or marsh hay, which receives a layer of the best dirt available. Less comfortable to drive upon are such roads where all the sticks are laid lengthwise.

Roads built of fascines covered with good earth will last, when kept damp, from two to three years. Of course, these roads can only be built in localities where there is plenty of wood. About three per cent. of roadways in California belong to this class.

ESTIMATE OF COST FOR NEW BROKEN-STONE ROADS.

In level districts, with abundant building material, low charges for land damages or land acquisitions, one mile of real good road will cost about $4,000.

ROLLING.

Advantages of Rolling.

Rolled roads are better and more permanent than those which are compacted by traffic. They also suffer less by the loosening effect of frost and thawing. The rolling of broken stones should be done rapidly to prevent the soiling of the road metal by dirt.

Rolling saves a large quantity of broken stone, for if the road metal be compacted by traffic, many of its fragments are crushed or rounded before the metal is firm, in which case it becomes unfit to form a rigid topping. Road metal lost in this way will pay for rolling, for the reason that as much as half of it is often thus spoiled before it becomes consolidated by traffic. Vehicles and draught animals forced to compact loose road metal are much damaged, which loss, it is true, does not directly affect the road-building

authorities, but is certainly a serious item when viewed from an economical standpoint. The above also holds good in regard to maintenance and repair of roads done by compacting broken-stone layers by passing traffic.

The Horse Rollers. Description of the Popular Hanovarian Pattern.

The diameter of the rolling cylinder is about 6 feet. Rolling cylinders of smaller diameter have this disadvantage, that if of the same weight per inch of width as those of larger diameters, they sink deeper into the loose broken stone, and thus, in an increased measure, push ahead the road metal in wave-like masses, and thus round off the angular fragments very much. Again, the required propelling force increases with the decrease of the diameter of the rolling cylinder. On the other hand the larger diameter increases the danger of upsetting with rollers of equal widths. On that account the width of the cylinders should not be too small, from 40 inches to 60 inches being the usual width. Greater width is objectionable on account of the curvature of the transverse contour of the road. With too large a width the crushing of the road metal in some spots and the imperfect compacting in others being observable.

In rolling it is important to be able to change, within considerable limits, the weight of the roller, because :

1st. The newly-spread stone fragments are most readily fixed in position when exposed to moderate pressure in the beginning, once bedded they should be rolled under maximum pressure. This has the convenience that the movement of the unballasted roller requires about the same tractive force on loose road metal as the ballasted roller on the more compacted surfacing.

2nd. Experience teaches that the time needed for finishing diminishes with the increased weight of rollers. It appears that with average road metal a pressure of the unballasted roller of from 72 to 110 pounds per inch, and of from 370 to 460 pounds per inch of width of ballasted roller is preferable.

3rd. Not only the character of the broken stone, but also the resistance of the sub-stratum must be considered in the selection of roller weight, on soft or wet subsoil heavy rollers will cause a distortion of the road bed.

The ballasting of the roller is effected either by filling the interior of the roller with stone blocks, gravel, sand, or, which is still better, with water, or by charging the ballast boxes secured above

the roller, or on the pole frame. The latter are objectionable because they increase the weight upon the axle-tree and thus augment the axle friction. Average weight of unballasted Hanovarian roller 2 to 3 tons; if filled with water 3 to 4 tons; and with water filling and charged ballast boxes, 4 to 5 tons. The largest weight admissible for horse rollers depends upon the tractive force of an eight-horse team.

The demand to so far increase the weight of the roller that it corresponds to the cart-tire pressure exerted by the heaviest teams frequenting the road cannot usually be met.

The brakes form an important part of the rollers; they are maneuvered by means of hand wheel and screw. To keep the rolling cylinder clean, detachable scrape irons are provided.

It is important to observe that the harder the horses pull, the more of the road covering they tear up; for this reason it is better to employ rather too large a span than too small a one in road rolling.

Horse road rollers are manufactured in our country by Addyston, Austin, Pope, the National Machinery Co., the American Road Machine Co., etc. Steam road rollers are manufactured in our country by the Harrisburg Foundry and Machine Works, and the O. S. Kelly Co.

The Advantages and Shortcomings of Horse and Steam Rollers.

1st. The steam rollers, by doing more work, reduce the time required for constructing or repairing roads. The superiority of steam rollers is partly due to the facility with which they are moved forwards and backwards; partly to the absence of the disturbing action upon the road surface by the horses' hoofs in connection with horse road rolling, and partly to the larger weight per inch of roller width.

2nd. Steam rollers certainly work cheaper than horse rollers, when compacting road metal which is not only very hard in character but resisting to rolling.

3rd. Since the steam rollers achieve a more thorough compression of the road covering, steam-rolled roads need less repairs.

4th. The facility with which steam rollers reverse admits of limiting the rolling to a comparatively short length of roadway, which is an important item when repairing roadways of considerable traffic.

5th. Steam rollers work well up to 10 per cent. grades and even more, when horse rollers cease to give satisfactory results.

6th. The more expensive steam roller will only pay fair interests on the capital invested when continually employed. In counties where rolling is needed only on comparatively short stretches which are far apart, the exclusive use of horse rollers proves more economical, because the lower price of horse rollers permits the purchase of a number of them.

7th. The economical use of steam rollers requires a systematic preparation in regard to regular supply of road material.

8th. A disadvantage of most steam rollers when compared with horse rollers consists in that the weight of the steam rollers can neither be much reduced for temporary needs nor considerably increased by additional ballast.

9th. The selection of a crew and the preservation of steam rollers will present some difficulties in practice, for the reason that the former must consist of skillful help, and that the latter necessitates considerable supplies, and in the event of larger damages having been done to the machine, the transportation of steam rollers to distant and well-equipped machine shops.

10th. Special precautions must be taken before the heavy steam rollers can be allowed to pass over bridges. In many cases it will be necessary to decide first whether the bridge be strong enough, or whether additional re-enforcing is necessary, or whether the passing of the steam roller across the bridge had better be given up entirely.

11th. Steam rolling must be dispensed with on road coverings made of a road metal of inferior hardness, that is, on fragments which, although they may not crush, may be likely to deteriorate under the heavy weight of rollers. This also holds good on roads where pipes and other fragile constructive elements are laid close to the surface.

12th. With careful maneuvering, horses accustom themselves readily to steam rollers. The use of the steam whistle should not be permitted.

Execution of Rolling.

Each layer of the road should be separately rolled. The length of each trip with horse rollers should, if possible, be so selected that the draught animals can make it without overexertion. At the end of every trip they get a short and well-needed rest. Distances from 1,300 to 2,000 feet are suitable. If there are two rollers at hand it is well to work them simultaneously on the same stretch, in order to reduce the time required for finishing by one half. The velocity of the horse roller should correspond to the most comfortable gait of

the span, say at a rate of 8,200 feet per hour, or 2.3 feet per second, which can be increased to 3.3 feet per second under favorable circumstances.

At the commencement light roller weight is desirable, therefore the application of unballasted rollers, in order to crowd the loose fragments together; an increase in roller weight not being justified until the layer is somewhat compacted. Commence work therefore with an unballasted horse roller, and gradually raise its weight by means of ballast. With steam rollers, that do not ordinarily allow any increase in weight by ballasting, it is good policy to begin with the lighter ones, and to finish up with the heaviest, provided a number of them are at disposal; or we may compact with horse rollers first, and finish with steam rollers.

The first rolling is done along the borders of the roadway; it is customary that the rollers move up on one side and return on the other. Each succeeding trip follows in the same direction, so that each spot of the covering is always touched in the same sense. Besides that, each succeeding trip overlaps the edge of the preceding one while covering a strip closer to the middle of the road. When the surface near the border or shoulder of the roadway has commenced to consolidate, and there is therefore little fear of a noticeable give toward these sides, then the rolling in the middle of the roadway may be begun. This method of rolling, beginning at the two sides and ending in the middle, is continually repeated.

The road should be watered if there is want of natural moisture. This can be attended to with water carts. Pumps are also applicable where side ditches convey water. Moisture reduces the movement of the stones, prevents the rounding of the angular fragments and accelerates compacting. Too much moisture, particularly with heavy rollers, causes softening of the foundation. To reduce the expenses of water supply, wet weather is preferable for this work. Rolling has to be suspended when by continued wet weather the subsoil has become so soft as to cause a deformation of the road mass upon rolling over it. After the rolling has so far advanced that the displacement of the stone bed ahead of the roller ceases, then the gaps and irregularities, and eventually the holes caused by the draught animals, are filled with sharp angular fragments. As soon as the topping has consolidated far enough that no further movement is visible upon walking over it, then the hogging or detritus from stone breaking, or specially selected binding material, preferably ferruginous gravel, is spread. This is worked into the bed by sharp brooming

executed in a direction across the road. Experience teaches that the binding material should be introduced at the beginning of the last third of the total time needed for rolling.

The spreading and brooming of the binding material is continued without interruption to the rolling, until the voids between the fragments of the road covering are filled as much as possible. When this state is reached, and the topping is firm, the rolling is finished. The necessary number of trips over each spot depends upon the character of the road metal, the thickness of the layer, the subsoil, the weight of the rollers, and the weather. With horse rollers from twenty-five to one hundred trips are required.

With 12½-ton steam rollers and 1½ inches thickness of layer, thirty-three trips over every strip of pavement were needed, and with 4½ inches thickness of layer 143 trips over every point of topping were required. Again, with 2½ inches thickness of triassic limestone as road metal, thrirty-three trips, and with basalt, one hundred and ten trips ; weight of steam roller in this case 13½ tons.

A light steam roller will compact from 140 to 170 cubic feet, and a horse roller from 106 to 140 cubic feet per hour of road metal of average hardness and spread in layers of usual thickness.

It is well to regulate the traffic over new roads rolled with light rollers. This is accomplished by means of barriers that partially blockade the road, and gradually expose all points of the topping to the traffic, thusly preventing the cutting of ruts while assisting in systematically compacting the roadway. Finally it is very useful to roll new roads again, even if only a few times, shortly after they are opened to traffic. This is particularly desirable after the first thawing out of the new road.

MAINTENANCE.

Since moisture on a road is particularly hurtful, the turning off of the storm water is to be most carefully looked after. To facilitate the discharge of the surface water from the topping, and to satisfy the demands of commerce, the road must be kept clean and smooth, and on established grades. The removal of vegetation is better done during wet weather. Of great importance to the maintenance of broken-stone roads are the use of barriers. Stones are generally employed as such, more rarely wooden horses. With these the track is changed either from a straight to a gently curved line—cross barriers ; or the track is shifted in parallel sections—parallel barriers. In the former method barriers are alternately placed on both sides

of the roadway about 250 feet apart, but under all circumstances they must leave a road width of 15 feet unobstructed. Such barriers force the vehicles to move in gentle serpentines, and by so doing the cutting of ruts is prevented. From time to time the barriers are longitudinally advanced, so as to cause every point of the road to become thoroughly consolidated by one or the other serpentine.

Less effective, but also less troublesome for the traffic, is the employment of parallel barriers, which are placed only on one side of the roadway. They temporarily withdraw from the traffic parallel strips of roadway on which ruts commence to show. The roads ought not to be barred between sunset and sunrise. It is well to keep these barriers whitewashed in order to make them more distinguishable. Intelligent use of these blocking systems will impede the destruction of the road topping by ruts.

Removal of Mud.

Another important labor for the preservation of broken-stone, gravel and dirt roads is the cleaning from mud, which process assists in preventing the penetration of moisture into the roadbed, and aids in drying the road by better exposure to sun and wind.

The removal of sticky mud is effected by means of mud scrapers, and of the more fluid mass by means of brooms. The mud is generally drawn off to the side, and when sufficiently hardened is piled up. Portions of this material may be used for repairing slopes, and the remainder is turned over to adjacent farms as manure, etc. Where such a disposition is not possible the mud must be carted off, which is an expensive operation. Its removal should be repeated whenever needed. Generally it is found sufficient to attend to this class of work twice a year, in the fall and spring; but in the latter season it must be done in such a manner as to retain a thin layer of mud, which by hardening serves to protect the metaled portion of the road in the summer time. A laborer is able to clean from 700 to 950 square yards of road topping in one day.

Roads having filtering sand foundations require scarcely any cleaning, if their broken-stone coverings produce but little mud. Recently mud-scraping machines have been introduced, of which one of the most popular is Plockhorst's, of Brunswick.* These machines are moved by two horses. They will clean about 9,000 square yards per hour, and cause a saving of over 30 per cent. in cost, even if compared with very cheap hand labor.

* The Barnard Castle street scraper is similar in construction.

The Graveling of Broken-Stone Roads.

The spreading of gravel on roads, particularly after they begin to deteriorate, undoubtedly facilitates traffic. Whether this would also cause a saving in the expense of roadway preservation led Gravenhorst to the following investigations:

On each of four different roadways he selected three experimental reaches, practically level, of which one was not graveled; one at the usual rate of 35 cubic feet to 44 cubic feet of gravel per 320 feet in length, and 12 feet in width of roadway; while the third was liberally ballasted with gravel at the rate of 70 to 87 cubic feet. The average of the results of wear on all twelve experimental stretches, after six years of observations, amounted to $\frac{1}{4}$ inch per annum for the ungraveled roadway sections; for roads graveled at the usual rate $\frac{1}{8}$ inch; and for roads liberally graveled $\frac{5}{32}$ inch.

These investigations prove the advantage of graveling road coverings, and indicate that it is economically advantageous as long as the cost for gravel does not exceed half the cost of the broken stone supply. Instead of gravel, coarse sand may be used. In very dry sections, and exposed to winds, loamy gravel, or even earthy material, is preferable to clean sand as a cover for roadway topping. The covering with gravel, or with coarse sand respectively, is done on calm and wet days during spring and summer. A laborer can gravel about 1,000 feet of roadway of ordinary width per day.

Maintenance of Broken-Stone Roads.

Two different systems are employed to maintain the roadway in its original condition. The one, the continuous maintenance by patching, replaces all loss in the original thickness and shape of the roadway caused by wear and tear, in the manner of continuous repairs. For instance, if the road has lost its transverse contour, the deficiency is supplied by filling up the depressions. This filling should be done in two layers, if more than $2\frac{1}{2}$ inches in height are worn off, the second layer to be spread when the first is compacted by traffic.

Ruts and holes of slight depth in the otherwise perfect topping are filled with gravel or small broken stones. The filling should be done during damp weather. A dry road surface is roughened by picks before the filling is deposited. Material of poor binding qualities used as filling should be rammed down.

This building up by filling should be done in such a manner so as not to induce the vehicles to evade the leveled-up spots, and thus

prevent the consolidating of the fresh filling. Filling, therefore, should be done uniformly on all parts of the topping, in order to offer everywhere an equally good surface. Such repairs should not exceed more than 10 feet in length and 6 feet in width at any place. Long ruts, due to neglectful maintenance, should be filled in in short sections, because vehicles might otherwise be disposed to avoid the repaired parts.

This system of repairing, while not excluding the use of rollers in exceptional cases, is very uneconomical in the amount of broken stone required, and is only justifiable under conditions of a plentiful supply. Again, the roadway is seldom entirely smooth and firm under this treatment, and the patching system greatly increases the work of road laborers.

The other system, the periodical maintenance or topping system, permits the wear and tear of the roadway to go on to a certain limit, before entering upon the restoration of the original longitudinal profile and cross section, when all that which was worn off during the course of years is replaced and secured in one layer. This system does not entirely exclude small repairs, but limits them to the timely filling in of holes and ruts in order to check more extensive damages to the roadway. The surface is kept smooth in this manner until its advancing wear necessitates a new topping.

Before the road metal is spread there should be cut along the borders of the road shallow wedge-shaped trenches, having their vertical faces exteriorly. The new metal is then spread upon the bed in the required thickness, and finds its abutments in the vertical faces of these trenches. The new metal is spread in such thickness that the repaired section will eventually assume the height of the adjacent topping. Binding material is not used at this stage, because the wheels of passing vehicles supply such from the neighboring road surfaces. After the repaired sections become compacted, however, the spreading of hogging or gravel to some extent is advisable. Road rollers should be used wherever a considerable amount of road metal is employed in such repairs, say more than 3 cubic yards of broken stone per 1,200 square yards of road surface.

The question, whether a roadway should be retopped or not is best solved by opening it at several points in order to establish without doubt its true thickness. Experience teaches that the maintenance of a roadway is reduced to a minimum if it is always kept clean, firm and well side-sloped. Where the wear is more particularly confined to the middle of wide roads it is customary to repair this

part by itself by a coating of about 15 feet in width. A wear of more than 4 inches should never be permitted, for the reason that heavy layers are very difficult to roll.

The retopping of roads should be done systematically. If, for instance, the permissible wear on a long roadway amount to 3 inches, and the yearly loss by wear is ⅓ of an inch in thickness, then a new coating of 3 inches is required every nine years. Hence we repair the ninth part of the total length of the roadway in consideration every year. It is not to be understood that we are always to continue the retopping where we left off the last year, on the contrary, we should pick out for repairs the worst sections first.

The broken stone used for small repairs should be of a somewhat finer structure than that employed for the new topping. If there be danger that upon rolling the new road metal will move out of place, owing to the particular smoothness and firmness of the roadway, then a roughening by picks of the entire surface, or grooving across the roadway, say every yard, is customary. To facilitate the roughening of the old topping, the better class of steam roller is provided with holes for the insertion of strong iron spurs, which, when passing over the roadway, tear it up by shoving aside the fragments. Mothiron has constructed a special apparatus for this purpose, the application of which reduces the cost of grooving very considerably when compared with hand labor.

The retopping of roadways should be carried out at once over the whole width, wherever possible without too great an inconvenience to the traffic. Deep holes and ruts are repaired previous to the spreading of the material for the new layer. The best time to execute this work is during damp weather. In the dry season sprinkling is required. This topping system in connection with road rolling is preferable on such highways, which require large quantities of road metal in repairing. It is advantageous to exclude, in this event, the use of cheap and poor road metal for the better material, even if much more expensive. The employment of limestone for resurfacing roadways of important traffic is disappearing more and more on that account.

Road Sprinkling.

The amount of water allowed for each sprinkling to keep our California roads from becoming dusty during the dry season, should not be less than 270 gallons per 1,000 square yards, which quantity applied three times a day would give 810 gallons of water per 1,000

square yards of road surface. Fine sprinklers, and frequent application thereof, in moderation, is preferable to the more rare flooding process, both on account of road preservation and for the comfort of travel.

PERSONEL.

Road Overseers and Road Laborers on European Highways.

It is necessarily indispensable to bring up a schooled and reliable corps of roadway labor. Some administrations permanently employ the most necessary number of men, others temporarily engage competent settlers as sub-contractors on agreement. With the customary periodical roadway repairs—the system of periodical road-topping—a permanent road laborer for every three to five miles of broken stone or graveled highways is sufficient. The reaches to be attended to by one permanent laborer are, of course, shorter where the patch system is adopted, a mile and a half of metaled roadway being a fair average length. With dirt roads, the men connected with the road machine, sprinkling cart, and road roller, replace these local laborers.

The immediate superior of the road laborers is the road overseer. He receives a yearly salary, including reimbursement of official traveling expenses and stationery, and is furnished — this may be amusing to you — with a safety velocipede. Although this proposition might arouse your risibility for a moment, when picturing to you a certain class of road men mounted on bicycles, still there are undeniable merits in it. If the overseer is obliged to inspect his district while riding on a velocipede, he will, by his own sufferings, readily find the bad places he might otherwise overlook, and thus become personally interested to a high degree in the perfection of the roadway in his district. The proportion of one overseer to twelve permanent laborers is found in good organizations.

The method of employing labor on our highways will depend upon the locality and surrounding circumstances. Very much more can be done with organized labor under competent direction, than with the hap-hazard system in vogue. Road-making is an art, and it requires men trained to the work to accomplish lasting results.

The present hard times place us in the position to give employment on the roadways to the idle and deserving, and receiving in return a good day's work at moderate figures.

REGULAR MEETING, OCTOBER 6, 1893.

PROCEEDINGS.

MINUTES.

The meeting was called to order by Vice-President Marx.

The minutes of the last regular meeting were read and approved.

The following gentlemen were elected:

For Members:

Edward N. Eager, County Surveyor.....Solano County, Cal.
R. J. Rolfson, Mechanical Engineer.....San Francisco, Cal.
R. M. Vail, Mining Engineer..... San Diego, Cal.
J. S. Walker, Civil Engineer.....Samoa.

The following proposition was read and referred to the Executive Committee:

F. E. Trask, Irrigation Engineer; proposed by W. H. Sanders, A. Lietz and Geo. F. Schild.

A letter was read from the Secretary of the Irrigation Congress, to be held at Los Angeles, October 10th, inviting the Technical Society to send a delegate to the coming Congress. The chair appointed Mr. David C. Henny.

Mr. Luther Wagoner submitted a paper, which was read by title, "On the Duty of the California Wet-Crushing Stamp Mill."

Mr. D. C. Henny delivered an address, with a mathematical treatise, entitled: "Supports Required for Curves in Pressure Pipes." The discussion of this subject was held over for a subsequent meeting, and the paper will be published in full in the next issue of the Transactions.

The delegates to the State Road Convention, held at Sacramento, September 7th, made a verbal report, stating that the members, J. H. Striedinger, O. H. Buckman and Otto von Geldern, had attended the Convention on behalf of the Technical Society, and participated in the discussion of the important subject.

The principal object of Messrs. Striedinger and von Geldern in the movement made for good roads was to submit to the Convention

a collection of important data taken from the more recent authorities on road building, and to bring about a discussion of the most approved methods of highway construction. Such data had been carefully prepared, but on account of the limited time at the disposal of the Convention, in which the question of creating the necessary funds for the improvement of the State's highways was of primary interest, the reading and discussion of this paper had to be omitted. It was gratefully accepted, however, and the appreciation therefor duly expressed; it will appear in due time as a part of the proceedings of the Convention.

The Directors of the Technical Society having requested the delegates to bring the paper before the Society, it was proposed that its contents be briefly gone over at this meeting, and the Secretary proceeded to read extracts therefrom, which he asked the Society to receive as a part of the report of the delegates, explaining their particular duties in connection with this Convention. The report was received, and the paper submitted to the Publication Committee.

Adjourned. OTTO VON GELDERN, *Sec'y.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME X. No. 10.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

EFFECT OF CURVES IN PRESSURE PIPES UPON THE REQUIRED SUPPORT.

BY D. C. HENNY, Mem. Tech. Soc.

(Read Oct. 6th, 1893.)

The following investigation of the pressures in a curved pipe line and their resultants, was suggested to the author by a case, which recently occurred in his practice. An inverted siphon, 52 inches in diameter, built of wooden stave pipe,* was laid for the purpose of carrying flume water across a deep cañon. As the velocity in the pipe was to be over 8 feet per second, it was thought advisable to avoid short elbows, and the profile of the cañon along the line of pipe, having the shape of a **V**, rendered it necessary, in order to round off the sharp angle at the bottom, to build a trestle. The curve, to which the pipe was laid on this trestle, was not a succession of chords, but part of a true circle with a radius of 300 feet, and with the axis lying in a vertical plane.

It may at first sight appear that the easy curving of the pipe can have little or no effect on the load to be supported by the trestle; and it has been argued by many engineers, that it is impossible to put more load on any part of the trestle than the weight of the pipe

*See, for a detailed description of wooden stave pipe, a paper by the same author, Transactions Technical Society Pacific Coast, Volume IX, Number 2.

and water immediately over it; that because the pipe is round, an increase of pressure at the bottom of the section is offset by an equal increase at the top, so that the internal pressure can have no effect on the load; that a boiler under high pressure weighs no more than a boiler under low pressure, and that consequently the pressure in the pipe has nothing to do with the load on the trestle, etc.

It must be understood at the outset that all this is admitted for a straight pipe. A change of direction, however, whether caused by an angle at each joint, or by a gradual curving of the pipe itself, causes, in connection with the internal pressures, a thrust, lying in the same plane as the axis of the pipe line, and unless this plane be horizontal, this thrust will add to or take away from the downward load. In the actual case mentioned, the effect of the curvature upon the load at the bottom of the 52-inch inverted siphon, where the pressure is about 70 pounds per square inch, amounts, as will hereafter be shown, to over 53 per cent. of the weight of the water, and to over 41 per cent. of the combined weight of water and pipe. Where the pipe is supported by a structure, whose dimensions are calculated from the maximum load, the effect of the curvature is therefore not a matter of mathematical refinement but of practical and vital importance.

Let us consider two parallel pipes A, connected to a 180 degree bend B by means of slip joints (see Fig. 1). In case these pipes be filled with a fluid at rest and under pressure it is evident that the bend B is liable to be blown off. Imagine the fluid in the pipes A removed, and forces p substituted.

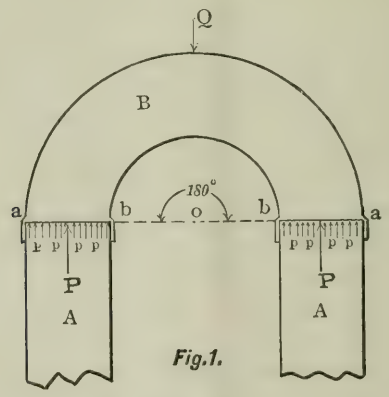


Fig.1.

The aggregate P of the forces p for each section $a\ b$ will thus equal $\pi r^2 p$, r being the radius of the pipe in inches, and p the pres-

sure per square inch. Now if it be desired to hold the bend B in place, a force Q or its equivalent must be applied in opposite direction to P, and equalling $2\ P = 2\ \pi\ r^2\ p$. This resisting force Q may be found in the reaction caused by a heavy mass placed along the outside of the curve, or the bend may be anchored from its center, or if the joints are strong and rigid the anchorage may be supplied by the straight pipes A themselves, in each of which a tension will then be induced equal to P.

Let us now consider two straight pipes A, joined by a bend B, with a central angle α.

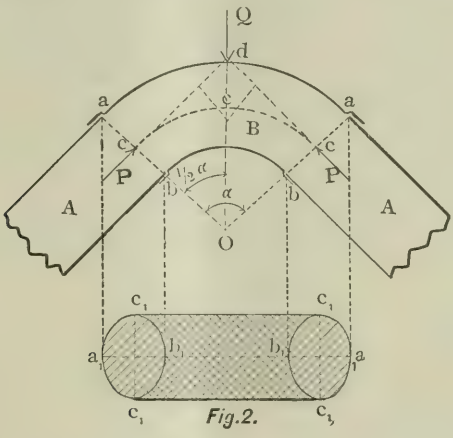


Fig.2.

Again we can imagine the fluid in the pipes A removed and replaced by forces P. The force Q required to prevent motion is equal and in opposite direction to the resultant of the forces P, and may be found by the simple construction of a diagram of forces :

$$Q = 2\ P \sin.\ \tfrac{1}{2}\ \alpha = 2\ \pi\ r^2\ p \sin.\ \tfrac{1}{2}\ \alpha \ldots\ldots\ldots\ldots (1)$$

The resistance to motion may again be found in the reaction caused by an opposing mass, placed along the outside of the curve, or the bend B may be anchored from the direction of the center of the curve O, or by the pipes A themselves if the joints $a\ b$ are capable of withstanding strains P without injury.

In ordinary water-works practice, caulked lead joints are depended upon, together with the support furnished by the back filling material, to hold the elbow in place in the case of small pipes. For diameters of 16 inches or over it is customary, however, to take special precautions to prevent too severe a strain upon the joints at the elbows, and either props or masonry are placed along the outside of the bends.

The curved pipe and the fluid it contains, have been so far treated as forming one single body. Considering the elbow by itself, on the inside of whose surface the fluid exerts pressures, at all points perpendicular to the surface, we observe that, cutting the curve in two parts by a cylindrical plane through the axis $c\ c\ c$, the surface of the outside part exceeds that of the inside part, and, supposing the pressure p of the fluid to be the same at all points, that the pressures on these surfaces cannot neutralize each other as in the case of a straight pipe, but must leave a resultant.

If we consider an element $A\ B\ C\ D$, against which there is exerted a pressure p per square inch, the total pressure upon this element is $A\ B\ C\ D \times p$, and its component parallel to a line $E\ F$ is $A\ B\ C\ D \times p \times$ cos. θ.

Projecting $A\ B\ C\ D$ upon a plane perpendicular to $E\ F$, we have

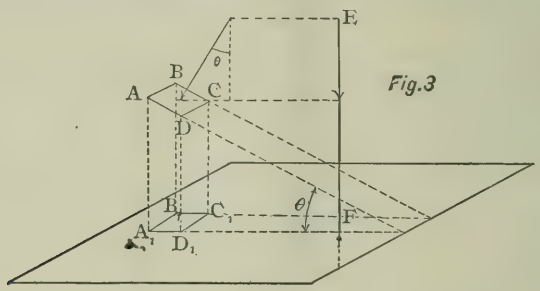


Fig.3

$A_1\ B_1\ C_1\ D_1 = A\ B\ C\ D \times$ cos. θ, and consequently the component of the pressure upon $A\ B\ C\ D$ parallel to $E\ F$ equals $p \times$ the projection of $A\ B\ C\ D$ upon a plane perpendicular to $E\ F$.

Applying this general theorem to the case illustrated in Fig. 2, we find that the aggregate of the components of all pressures upon the outside part $c\ a\ a\ c$, parallel to $O\ d$, and acting away from O, equals $p \times$ the area $c_1\ a_1\ c_1\ c_1\ a_1\ c_1$, and upon the inside part $b\ c\ c\ b$, parallel to $O\ d$ and acting toward O, equals $p \times$ the area $c_1\ b_1\ c_1\ c_1\ b_1\ c_1$ leaving a resultant away from $O =$

$$Q = p \times 2 \times \text{the area } a_1\ c_1\ b_1\ c_1 =$$
$$= 2\ p \times \text{the area of the circle } a\ c\ b\ c \times \text{sin. } \tfrac{1}{2}\ a =$$
$$= 2\ \pi\ r^2\ p \text{ sin. } \tfrac{1}{2}\ a, \text{ as per formula (1).}$$

It must be understood that in addition to the resisting force Q, an upward vertical force W equal to the weight of pipe and fluid is required to maintain equilibrium.

The doubt, which has been expressed by many engineers, regarding the actual existence of this eccentric effect of the fluid under pressure in an easy curving pipe, may in part be due to the fact, that save in the exceptional case of short and sharp bends in pipes of large diameter under heavy pressure, no special precautions need be taken where the pipe is buried, as the resistance of the back-filling material and the longitudinal strength of the joints are amply sufficient to prevent appreciable motion. This doubt and scepticism demands a thorough and fundamental treatment ot the problem, lest the objection be raised that conditions were assumed at variance with the actual facts, such as equality of pressure at top and bottom of pipe; and moreover the premises should be well defined.

The author in the further treatment of this subject will confine himself to the consideration of a pipe line of circular cross-section and uniform diameter, consisting of two straight pipe lines connected by a circular curve, the axis of the entire system lying in a vertical plane, the system being assumed to be filled with water. The water will first be considered in a condition of rest, standing in the straight ends at the same elevation.

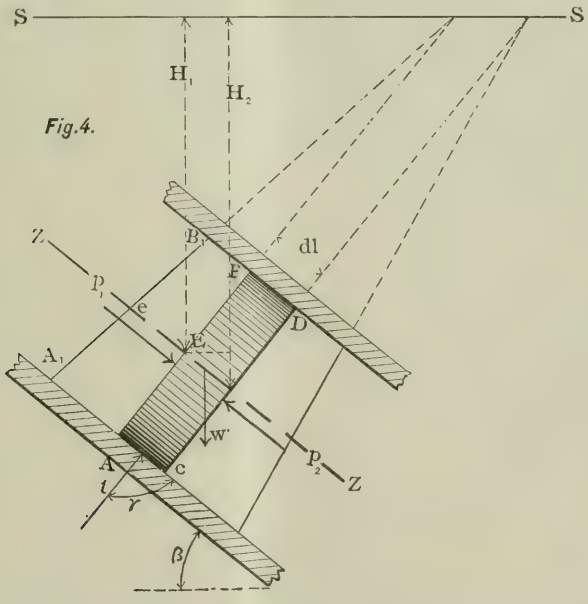


Fig.4.

Let *A B D C* be a body of water of infinitely short length *dl*, contained in a straight pipe, laid at an angle β with the horizontal, the bounding planes *A B* and *C D* being perpendicular to the axis of the pipe *Z Z*. The forces acting upon this body are:

First. Gravity, the combined effect of which is denoted by the force w.

Second. Pressures from the adjoining bodies of water, represented by the forces P_1 and P_2.

Third. Reactionary pressures from the pipe shell, of which t is the resultant.

A condition of rest being assumed, these forces must neutralize each other, and the resultant of any three of the forces must be equal and in opposite direction to the fourth force. The direction of w is vertical, and that of P_1 and P_2 is perpendicular to the sectional planes $A\ B$ and $C\ D$, and consequently parallel to the axis of the pipe. These forces lying in a central vertical plane the force t must also lie in this plane.

P_1 is the aggregate of the pressures upon the cross-section $A\ B$, which if $S\ S$ denotes a horizontal plane coinciding with the surface of the water, may be graphically represented by the frustrum of a cylinder $A\ B\ B_1\ A_1$, of which the circular section of the pipe $A\ B$ is the base, and of which the height at any point represents the pressure per square inch upon that point of the base. P_1 must thus be equal to the contents of the fustrum $= \pi\ r^2 \times e\ E$; r being one half the diameter of the pipe, which, as well as all other measures of length, is expressed in inches, and $e\ E$ being the pressure per square inch upon the center E of the section $A\ B$. Calling H_1 the depth of the point E below the water surface $S\ S$, and k the weight of a cubic inch of water in pounds:

$$e\ E = k \times H_1 \text{ and}$$
$$P_1 = k\ \pi\ r^2\ H_1 \text{ similarly.}$$
$$P_2 = k\ \pi\ r^2\ H_2$$

The contents of $A\ B\ D\ C$ equal $\pi\ r^2\ dl$, and consequently

$$w = k\ \pi\ r^2\ dl$$

Projecting all forces upon a line parallel to $Z\ Z$, we have

$$\begin{aligned} t \cos.\ \gamma &= P_2 - P_1 - W \sin.\ \beta = \\ &= k\ \pi\ r^2\ [H_2 - H_1 - dl \sin.\ \beta] = \\ &= k\ \pi\ r^2\ [dl \sin.\ \beta - dl \sin.\ \beta] = 0. \end{aligned}$$

Therefore $\gamma = 90$ degrees, and the direction of t is perpendicular to $Z\ Z$. Projecting upon a line perpendicular to $Z\ Z$ we have

$$t \sin.\ \gamma = t = w \cos.\ \beta = k\ \pi\ r^2\ dl \cos.\ \beta \ldots\ldots\ldots\ldots (2)$$

t, as stated, is the resultant of the reactionary pressures from the pipe upon the water, and may therefore also be determined from these pressures. The pressure q upon an elementary surface $M\,N\,O\,P$ equals its area $dl \times ds$ times the pressure per square inch p upon its center.

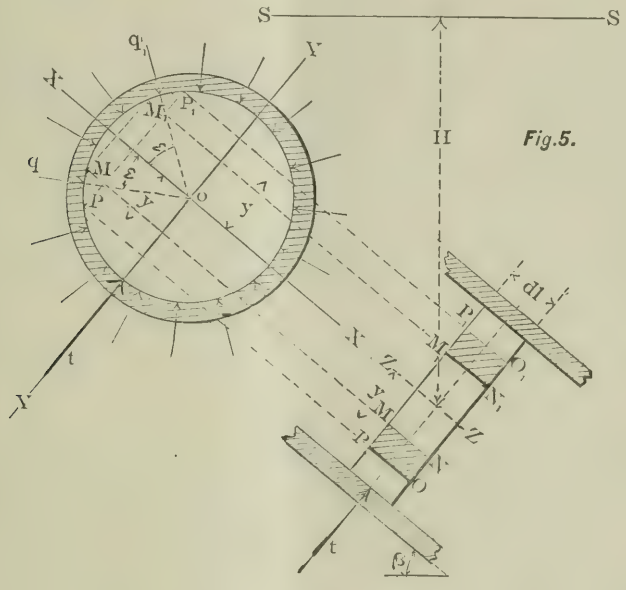


Fig.5.

$p = k\,(H + y \cos.\,\beta)$, and therefore $q = k\,dl\,(H + y \cos.\,\beta)\,ds$.

Similarly upon the elementary surface $M_1\,N_1\,O_1\,P_1$ the pressure $q_1 = k\,dl\,(H - y \cos.\,\beta)\,ds$. The pressures on the entire cylindrical surface of the body of water $A\,B\,D\,C$ are all grouped symmetrically in regard to the axis $Y\,Y$, therefore their components perpendicular to $Y\,Y$, neutralize each other, and their resultant is found by taking the aggregate of their components parallel to $Y\,Y$. Thus the component of q parallel to $Y\,Y$ is

$$q \sin.\,\xi = k\,dl\,(H + y \cos.\,\beta)\,ds \sin.\,\xi = \\ = k\,dl\,(H + y \cos.\,\beta)\,dx.$$

Similarly the component of q_1 parallel to $Y\,Y$, is

$$q_1 \sin.\,\xi = k\,dl\,(H - y \cos.\,\beta)\,dx.$$

These two components are in opposite directions, and leave a remainder $2\,k\,dl\,y \cos.\,\beta\,dx$, and the sum of these remainders

equals t, and is found by integration between the limits $x = -r$ and $x = +r$.

$$t = \int_{-r}^{+r} 2\,k\,dl\,y \cos.\,\beta\,dx = 2\,k\,dl \cos.\,\beta \int_{-r}^{+r} y\,dx =$$
$$= k\,\pi\,r^2\,dl \cos.\,\beta, \text{ as per formula (2)}$$

The load placed by the elementary body of water upon the elementary section of the pipe surrounding it equals t and acts in opposite direction. Since $t = w \cos.\,\beta$, the vertical component of t equals $w \cos.\,^2\beta$, so that it is plain that that part of the original weight w equaling $w - w \cos.\,^2\beta = w \sin.\,^2\beta$, is transmitted to and borne by some other portion of the pipe shell.

For any straight length of water body L, the total reactionary support T may be found by integration between the limits $l = o$ and $l = L$.

$$T = \Sigma_o^L t = \int_o^L k\,\pi\,r^2\,dl \cos.\,\beta = k\,\pi\,r^2\,L \cos.\,\beta = W \cos.\,\beta \ldots (3)$$

Let us now consider an elementary body of water $A\,B\,D\,C$ (see Fig. 6) contained in the curved part of the pipe, the radius of the curve to center of pipe being R (expressed in inches).

The effect of the adjoining water columns upon the end surfaces $A\,B$ and $C\,D$ may again be replaced by forces P_1 and P_2, which in this case, however, are not parallel. Their values are :

$$P_1 = k\,\pi\,r^2\,H_1^{\beta} \text{ and}$$
$$P_2 = k\,\pi\,r^2\,H_2^{\beta}$$

The remaining exterior forces acting upon the body of water are again :

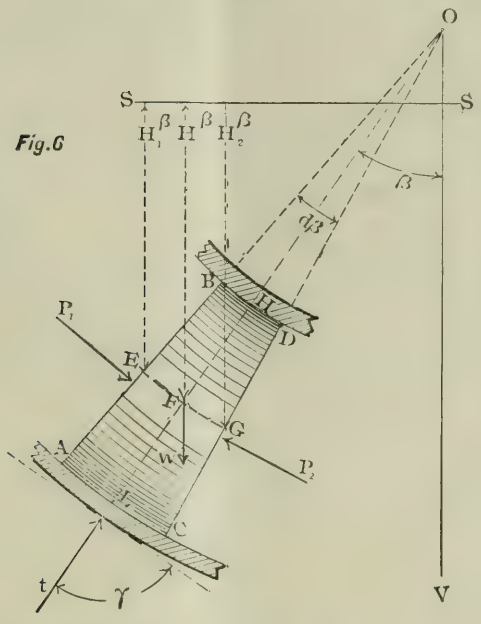
$$w = k\,\pi\,r^2\,E\,G = k\,\pi\,r^2\,dl$$

and the reactionary pressures from the pipe shell of which t is the resultant. Projecting these forces upon a line perpendicular to $O\,L$, we have

$$t \cos.\,\gamma = P_2 \cos.\,\tfrac{1}{2}\,d\,\beta - P_1 \cos.\,\tfrac{1}{2}\,d\,\beta - w \sin.\,\beta =$$
$$= P_2 - P_1 - w \sin.\,\beta =$$
$$= k\,\pi\,r^2 \left(H_2^{\beta} - H_1^{\beta} \right) - w \sin.\,\beta =$$
$$= k\,\pi\,r^2\,dl \sin.\,\beta - w \sin.\,\beta = 0.$$

Therefore $\gamma = 90$ degrees, and projecting upon a line parallel to $O\,L$ we have

Fig. 6



$t \sin. \gamma = t = P_1 \sin. \frac{1}{2} d\beta + P_2 \sin. \frac{1}{2} d\beta + w \cos. \beta$, or

$$t = w \cos. \beta + (P_1 + P_2) \sin. \tfrac{1}{2} d\beta.$$

$$P_1 + P_2 = k \pi r^2 \left(H_1^\beta + H_2^\beta \right) = 2 k \pi r^2 H^\beta$$

Calling the pressure upon a central section $H L = P$ we have

$$P = k \pi r^2 H^\beta \text{ and } P_1 + P_2 = 2 P, \text{ therefore}$$

$$t = w \cos. \beta + 2 P \sin. \tfrac{1}{2} d\beta \ldots\ldots\ldots\ldots\ldots (4).$$

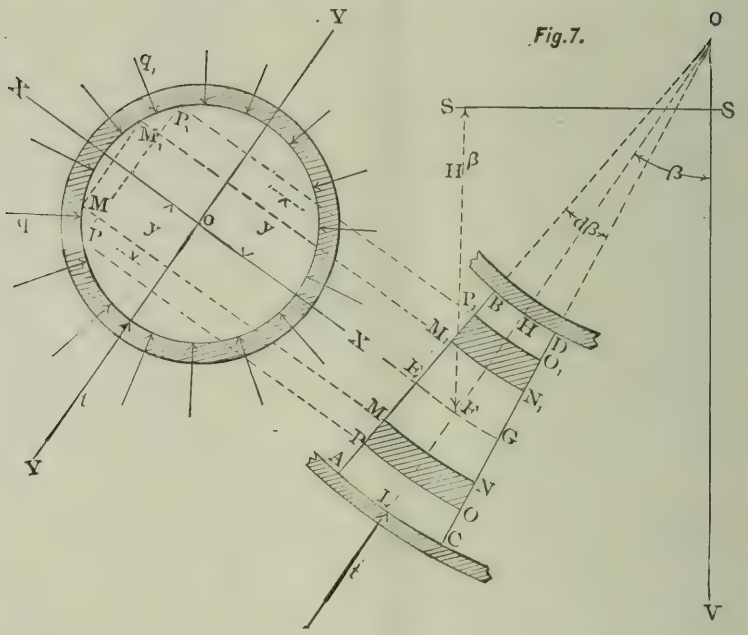
t may again be found directly from the reactionary pressures of the pipe shell upon the body of water $A\ B\ D\ C$. These are all grouped symmetrically in regard to the axis $Y\ Y$, and their resultant is therefore found by taking the aggregate of their components parallel to $Y\ Y$. (See Fig. 7).

The length of the wedge-shaped cylindrical body varies with the distance y from the axis $X\ X$ and is expressed for any point by the formula :

$$dl_y = (R \pm y)\, d\beta$$

Thus the area of the elementary surface $M\ N\ O\ P$ equals

$$M P \times (R + y)\, d\beta = d\beta\, (R \pm y)\, ds.$$



The pressure per square inch upon this surface is

$$k\ (H^{\beta} + y \cos.\ \beta)$$

and consequently the total pressure upon the elementary surface $M\ N\ O\ P$ equals

$$q = k\ (R + y)\ (H^{\beta} + y \cos.\ \beta)\ d\ \beta\ ds,$$

and its component, parallel to $Y\ Y$, is

$$k\ (R + y)\ (H^{\beta} + y \cos.\ \beta)\ d\ \beta\ dx.$$

This component away from O is in part offset by the component of a similar pressure $q_{,}$ upon the elementary surface $M_{,}\ N_{,}\ O_{,}\ P_{,}$, which is smaller for the double reason that the pressure per square inch is less, owing to a lesser depth below $S\ S$, and *the length of the element is less.* Therein lies the germ of the resultant thrust in curved pipes, which is the subject of this paper.

The value of the component of q, parallel to $H\ L$, is

$$k\ (R - y)\ (H^{\beta} - y \cos.\ \beta)\ d\ \beta\ dx,$$

and these two components of q and q_1 acting in opposite directions leave a remainder away from O equal to

$$k\, d\, \beta\, dx \left\{ (R + x)\ (H^{\beta} + y \cos.\ \beta) - (R - y)\ (H^{\beta} - y \cos.\ \beta) \right\}$$
$$= 2\, k\, d\, \beta\, dx \left\{ H^{\beta} y + R\, y \cos.\ \beta \right\} = 2\, k \left\{ H^{\beta} + R \cos.\ \beta \right\} d\, \beta\, y\, dx.$$

The aggregate of these remainders will constitute the resultant t, and is found by integration between the limits $x = -r$ and $x = +r$.

$$t = 2\, k \left\{ H^{\beta} + R \cos.\ \beta \right\} d\, \beta \int_{-r}^{+r} y\, dx =$$
$$= k\, \pi\, r^2 \left\{ R \cos.\ \beta + H^{\beta} \right\} d\, \beta \quad \ldots\ldots\ldots\ldots\ldots (5);$$

or
$$t = k\, \pi\, r^2\, R\, d\, \beta \cos.\ \beta + k\, \pi\, r^2\, H^{\beta} d\, \beta =$$
$$= w \cos.\ \beta + P\, d\, \beta =$$
$$= w \cos.\ \beta + 2\, P \sin.\ \tfrac{1}{2}\, d\, \beta, \text{ as per formula (4).}$$

Formula (4) is mathematically correct only for sections of infinitely small length, as the assumption was made, that the depth of the point F below the plane $S\,S$ is the mean of the depths of the points E and G below that plane. This is very nearly correct for sections with a small central angle α, and for such sections of pipe we may for all practical purposes use formula (4), which will then take the following form:

$$T = W \cos.\ \beta + 2\, P \sin.\ \tfrac{1}{2}\, \alpha \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6).$$

P being, as before, the pressure upon a central plane $H\,L$.

In case, however, the section considered be long, the value of α be large, and the exact value of T be desired, it may be arrived at by determining the resultant of the forces P_1 P_2 and W. (see Fig. 8).

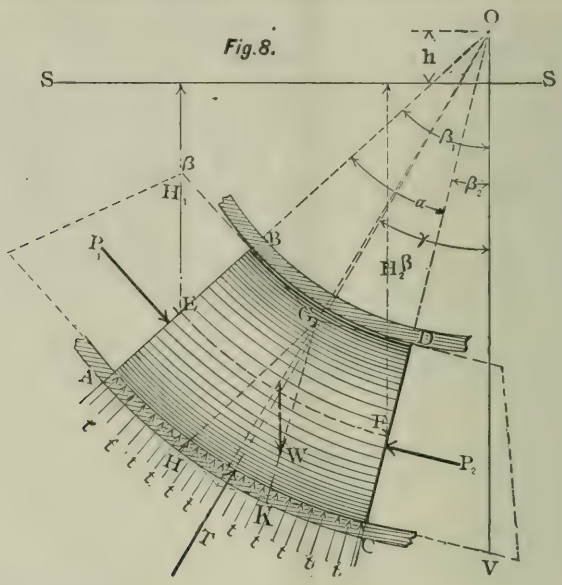
Projecting these forces upon a vertical line $O\ V$ we have

$$T \cos.\ \gamma = P_1 \sin.\ \beta_1 - P_2 \sin.\ \beta_2 + W \quad \ldots\ldots\ldots\ldots (7).$$

and projecting them upon a horizontal line we have

$$T \sin.\ \gamma = P_2 \cos.\ \beta_2 - P_1 \cos.\ \beta_1 \quad \ldots\ldots\ldots\ldots\ldots (8).$$

Fig. 8.



In these formulæ

$$P_1 = k \pi r^2 H_1^{\beta}$$
$$P_2 = k \pi r^2 H_2^{\beta}$$
$$W = R \alpha k \pi r^2$$

and therefore all values being known both T and γ may be readily determined. For the complete solution of the problem it remains to prove that the direction of T is always through the center of the curve O. This becomes evident when we consider that the resultant T of the exterior forces P_1, P_2 and W, acting upon the body of water $A\ B\ D\ C$, is at the same time the resultant of a number of forces t, as determined for each elementary section of pipe in formula (5). All these forces t passing through O, their resultant must also pass through O.

From formula (5) we have

$$t \cos. \beta = k \pi r^2 \left\{ R \cos. \beta + H^{\beta} \right\} \cos. \beta\, d\beta. \ldots . (9).$$

and
$$t \sin. \beta = k \pi r^2 \left\{ R \cos. \beta + H^{\beta} \right\} \sin. \beta\, d\beta. \ldots (10.$$

The values of $T \cos. \gamma$ and $T \sin. \gamma$, as expressed in formulæ (7) and (8), may also be found by the integration of the formulæ (9) and (10) between the limits $\beta = \beta_2$ and $\beta = \beta_1$.

$$T \cos.\ \gamma = k\,\pi\,r^2 \int_{\beta_2}^{\beta_1} \left\{ R \cos.\ \beta + H^{\beta} \right\} \cos.\ \beta\ d\,\beta.$$

$$H^{\beta} = R \cos.\ \beta - h.$$

$$T \cos.\ \gamma = k\,\pi\,r^2 \int_{\beta_2}^{\beta_1} (2\ R\ \cos.^2\beta\ d\,\beta - h \cos.\ \beta\ d\ \beta) =$$

$$= k\,\pi\,r^2 \left\{ R \int_{\beta_2}^{\beta_1} (1 + \cos.\ 2\,\beta)\ d\,\beta - h \int_{\beta_2}^{\beta_1} \cos.\ \beta\ d\,\beta \right\} =$$

$$= k\,\pi\,r^2\,[R\ (\beta_1 - \beta_2) + \tfrac{1}{2}\ R\ (\sin.\ 2\,\beta_1 - \sin.\ 2\,\beta_2) - h\ (\sin.\ \beta_1 - \sin.\ \beta_2)\ ] =$$

$$= k\,\pi\,r^2\,[\,R\ (\beta_1 - \beta_2) + R\ (\sin.\ \beta_1 \cos.\ \beta_1 - \sin.\ \beta_2 \cos.\ \beta_2) - h\ (\sin.\ \beta_1 - \sin.\ \beta_2\ )\ ] =$$

$$= k\,\pi\,r^2\,R\ (\beta_1 - \beta_2) + k\,\pi\,r^2\ (R \cos.\ \beta_1 - h)\ \sin.\ \beta_1 - k\,\pi\,r^2\ (R \cos.\ \beta_2 - h)\ \sin.\ \beta_2 =$$

$$= k\,\pi\,r^2\,R\ (\beta_1 - \beta_2) + k\,\pi\,r^2\,H_1^{\beta} \sin.\ \beta_1 - k\,\pi\,r^2 H_2^{\beta}\ \sin.\ \beta_2 =$$

$$= W + Q_1 \sin.\ \beta_1 - Q_2 \sin.\ \beta_2, \text{ as per formula (7).}$$

Also

$$T \sin.\ \gamma = k\,\pi\ r^2 \int_{\beta_2}^{\beta_1} [R \cos.\ \beta + H^{\beta}\ ] \sin.\ \beta\ d\,\beta =$$

$$= k\ \pi\ r^2 \int_{\beta_2}^{\beta_1} [2\ R \cos.\ \beta - h] \sin.\ \beta\ d\,\beta =$$

$$= k\ \pi\ r^2 \left\{ R \int_{\beta_2}^{\beta_1} 2 \sin.\ \beta \cos.\ \beta\ d\,\beta - h \int_{\beta_2}^{\beta_1} \sin.\ \beta\ d\,\beta \right\} =$$

$$= k\,\pi\,r^2\,[R\ \tfrac{1}{2}\ (\cos.\ 2\,\beta_2 - \cos.\ 2\,\beta_1) - h\ (\cos.\ \beta_2 - \cos.\ \beta_1)] =$$

$$= k\,\pi\,r^2\,[R\ (\cos.^2\beta_2 - \cos.^2\beta_1) - h\ (\cos.\ \beta_2 - \cos.\ \beta_1)\ ] =$$

$$= k\,\pi\,r^2\,(R \cos.\ \beta_2 - h) \cos.\ \beta_2 - k\,\pi\,r^2\,(R \cos.\ \beta_1 - h) \cos.\ \beta_1 =$$

$$= k\,\pi\,r^2\,H_2^{\beta} \cos.\ \beta_2 - k\,\pi\,r^2\,H_1^{\beta} \cos.\ \beta_1 =$$

$$= P_2 \cos.\ \beta_2 - P_1 \cos.\ \beta_1, \text{ as per formula (8).}$$

It has been thought advisable to work out these formulæ in order to thoroughly demonstrate the identity of the two methods pursued in determining the values of t and T, viz.: the first and simplest method, from the easily determined forces P_1, P_2 and W acting on the curved cylindrical body of water, and the second method, from the reactionary pressures exerted by the interior of the pipe upon this body of water.

Returning to formula (6)

$$T = W \cos. \beta + 2 P \sin. \tfrac{1}{2} \alpha$$

we find that the first term $W \cos. \beta$ expresses the load caused by the weight of the water, and is the same for a straight pipe laid at an angle β from the horizontal (see formula 3). The second term $2 P \sin. \frac{1}{2} \alpha$ represents the effect of the curvature upon the load, and both are acting in the same direction, away from O. The latter appears to be independent of the radius of the curve for a given central angle α, but for a given length of pipe L, measured along the chord, we have

$$L = 2 R \sin. \tfrac{1}{2} \alpha, \qquad \text{and}$$

$$2 P \sin. \tfrac{1}{2} \alpha = P \frac{L}{R}$$

Thus the larger R, the smaller will be the effect of the curvature upon the load for a given length of pipe. We may give formula (6) the following form :

$$T = W \cos. \beta + P \frac{L}{R} \quad \ldots\ldots\ldots (11)$$

In order to study the comparative effect of the weight of water and of the curvature of the pipe upon the load we can refer to the formula (5):

$$t = k \pi r^2 \left\{ R \cos. \beta + H^{\beta} \right\} d \beta.$$

in which again the first term expresses the effect of the weight of the water, and the second that of the curvature.

Therefore when $R \cos. \beta = H^{\beta}$, the weight of the water will have an equal effect upon the load as the curvature, which condition is complied with, when the plane $S\ S$ passes through the center of the curve O.

Referring to Fig. 8, it will be observed that in case the pipe between the sectional planes $A\ B$ and $C\ D$ consisted of halves of straight sections joining at an angle, as shown in dotted lines, P_1 and P_2 would remain unchanged, and that part of T that is owing to curvature (or change of direction) would also remain unchanged. The distribution of the forces t, of which T is the resultant, would be different however. From A to H and from C to K there would be only the load as figured for straight pipes, and the extra load owing to change of direction would be concentrated along $K\ H$. In

the case therefore of a pipe line consisting of straight sections, whose axes form a polygon, circumscribed to the circular axis, heretofore assumed, the extra loads due to change of direction will all be concentrated at the joints, and will aggregate the same as for a pipe line laid to a true circle.

Fig. 9 gives a graphical representation of the intensity of resultant thrust in a symmetrical system of pipes. The pipe line is represented by the single line $M M_1 K M_2 M_3$.

From formula (5) we have

$$t = k \pi r^2 \left\{ R \cos. \beta + H^{\beta} \right\} d \beta =$$

$$= k \pi r^2 \left\{ \cos. \beta + \frac{H^{\beta}}{R} \right\} R \, d \beta =$$

$$= k \pi r^2 \left\{ \cos. \beta + \frac{H^{\beta}}{R} \right\} dl \qquad \text{and}$$

$$\frac{t}{dl} = k \pi r^2 \cos. \beta + k \pi r^2 \frac{H^{\beta}}{R}$$

Supposing $K L = A b$ to be $= k \pi r^2$, then

$$A B = A b_1 = k \pi r^2 \cos. \beta.$$

Further, with $O A = R$, $A E = A G = H^{\beta}$ and $O D = K L = k \pi r^2$, we have

$$B C = E F = A E \frac{O D}{O A} = H^{\beta} \frac{k \pi r^2}{R} \quad \text{consequently}$$

$$\frac{t}{dl} = A B \text{ (effect of weight)} + B C \text{ (effect of curvature)}.$$

For any system of pipes the sum of the vertical components of all pressures exerted upon the water in these pipes must necessarily equal the weight of the water. Let us call —

Length of columns $M M_1$ and $M_2 M_3 = L$;
Depth of M_1 and M_2 below $S S = H$;
Weight of columns $M M_1$ and $M_2 M_3 = W$;
Weight of column $M_1 M_2 = W$.

In the system shown in Fig. 9, the aggregate support, which the water column $M M_1$ receives from the surrounding shell, equals

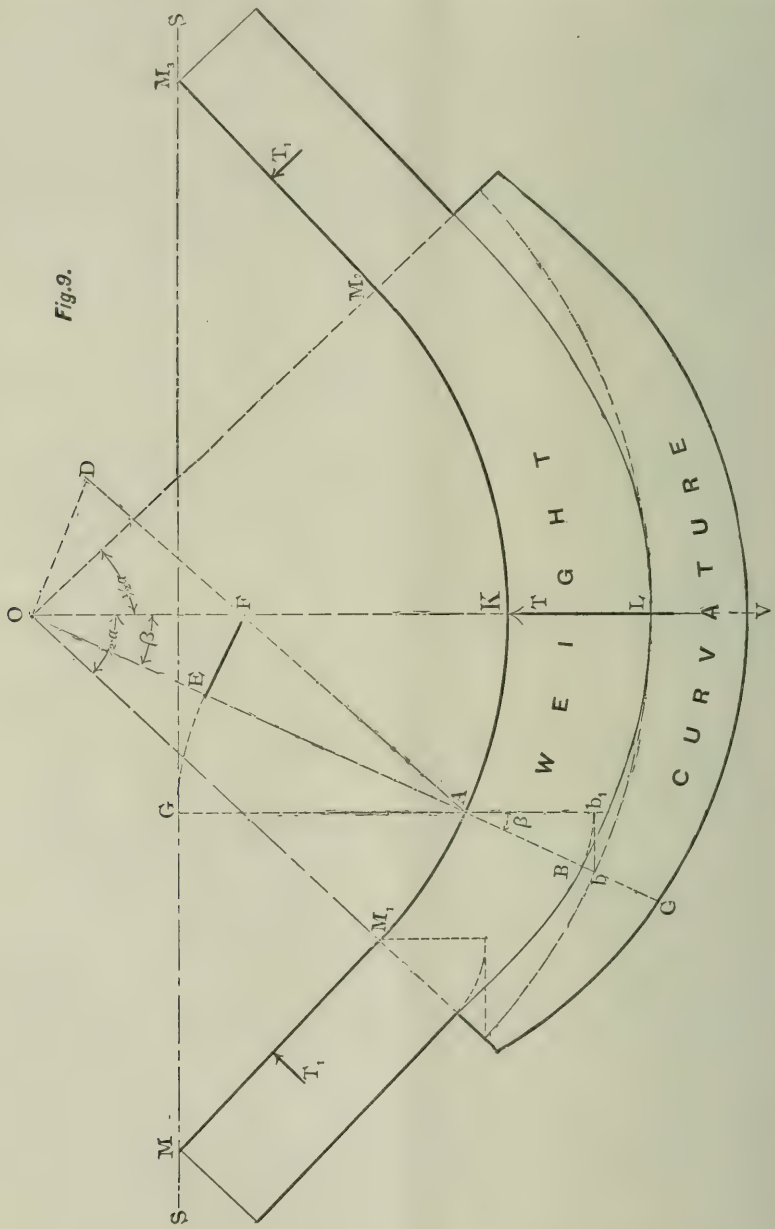


Fig. 9.

$T_1 = W_1 \cos. \frac{1}{2} \alpha$ (see formula 3). This is the same for the water column $M_2 M_3$. The aggregate support required by the curved column $M_1 M_2$ may be found from formulæ (7) and (8), in which P_1 and P_2 represent the pressures upon the normal sections at M_1 and M_2, P_1 being equal to P_2 and in which $\beta_1 = \frac{1}{2} \alpha$, and $\beta_2 = -\frac{1}{2} \alpha$. From formula (8) we have

$$T \sin. \gamma = P_1 \cos. \tfrac{1}{2} \alpha - P_2 \cos. \tfrac{1}{2} \alpha = 0, \text{ therefore } \gamma = 0.$$

From formula (7) $$T = P_1 \sin. \tfrac{1}{2} \alpha - P_2 \sin. (-\tfrac{1}{2} \alpha) + W =$$
$$= W + 2 P_1 \sin. \tfrac{1}{2} \alpha$$

The sum of the vertical components of these supporting forces must equal the weight of the water.

$$W_1 \cos.^2 \tfrac{1}{2} \alpha + W + 2 P_1 \sin. \tfrac{1}{2} \alpha + W_1 \cos.^2 \tfrac{1}{2} \alpha =$$
$$= 2 W_1 \cos.^2 \tfrac{1}{2} \alpha + W + 2 P_1 \sin. \tfrac{1}{2} \alpha =$$
$$= W + 2 W_1 - 2 W_1 \sin.^2 \tfrac{1}{2} \alpha + 2 P_1 \sin. \tfrac{1}{2} \alpha =$$
$$= W + 2 W_1 - 2 k \pi r^2 L_1 \sin.^2 \tfrac{1}{2} \alpha + 2 k \pi r^2 H \sin. \tfrac{1}{2} \alpha =$$
$$= W + 2 W_1 - 2 k \pi r^2 L_1 \sin.^2 \tfrac{1}{2} \alpha + 2 k \pi r^2 L_1 \sin.^2 \tfrac{1}{2} \alpha =$$
$$= W + 2 W_1$$

Thus we find that the effect of a curve in increasing the load is simply equivalent to an uneven distribution of weights.

In the case of a curve having the form of an arch, the effects of weight and curvature will be in opposite directions, and formula (11) will then assume the following form:

$$T = W \cos. \beta - P \frac{L}{R} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11a).$$

The values in this formula may be such as to cause T to become negative, necessitating the pipe to be anchored down to its supports to prevent it from rising.

It should be borne in mind, that the effect of the curvature upon the load, as expressed in the previous formulæ, is derived from the pressure of the water *at rest*, and that it is distinct from and additional to the effect of the centrifugal force with the water in motion. In that case, in determining the value of T from formula (11), the value of P should be found, not from the static head, as with the water at rest, but from the piezometric head.

The centrifugal force, which must be added to the forces heretofore considered, is approximately expressed in the following formula:

$$E = \frac{W \frac{v^2}{g}}{\frac{R}{12}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

v being the velocity of the water in feet per second, g the acceleration of gravity, and R, as before, the radius of curvature in inches.

Finally, the friction between water and inside surface of pipe induces a force, acting in a tangential direction, opposite to the motion of the water, which may be approximately expressed by the following formula:

$$K = W i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

in which i denotes the loss of head in feet, per foot of pipe.

The two latter forces are in ordinary cases of easy curving pipe, comparatively insignificant, and may be neglected. They are mentioned here merely for the sake of completeness.

These are the forces which act upon the interior of the pipe, grouped and integrated for convenient lengths or sections of pipe.

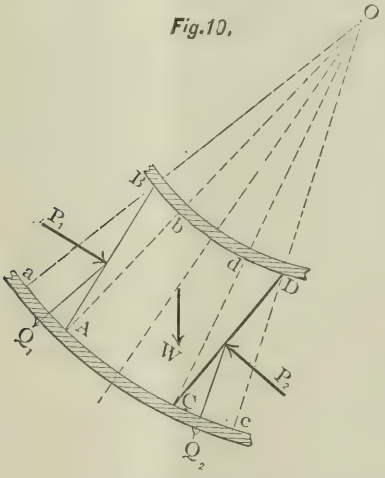
The pipe, where laid on top of the trestle, may, since it possesses great stiffness and lateral strength, under certain conditions be considered a structural part of the trestle, capable of transmitting loads from one point to another. And beyond the ends of the trestle, where the pipe rests against the hillsides, it may be strongly anchored, so that a part of the load coming upon the pipe at some point on the trestle, may be made to hang down from the solid support on the hillside, the pipe thus performing to some extent the duty of a cable in a suspension bridge. Such duty on the part of the pipe, especially if the trestle be a long and the curve an easy one, will develop great longitudinal strains in the pipe, and can only be performed when special provisions have been made in the way of anchorage, when the pipe is strong enough in a longitudinal direction, and when just sufficient settling of the trestle is provided to bring the required longitudinal strains in the pipe into play. It is generally not desirable to throw work of this kind upon a pipe line, and not economical to do so, when a trestle may cheaply be built of sufficient strength to do all the work of supporting the load, nor is it practicable to so adjust matters as to bring about a certain desired division of load between the trestle, transmitting its share downward, and the pipe transmitting its share sideways and upward.

In the case mentioned at the beginning of this paper, and to which the formulæ will be applied, no provisions in the nature of anchorage have been made, and the pipe simply rests without fasten-

ings of any kind upon sills, which on the trestle occur every three feet, and on the hillsides at greater distances. When the maximum load upon any portion of this trestle is to be determined, it is therefore decidedly unsafe to assume, that part of the load is carried by the pipe itself, and transmitted to distant points off the trestle, and each portion of the trestle should be made of sufficient strength to support the load, which comes upon the portion of the pipe it carries, in addition to the weight of this portion of the pipe itself, if not considered part of the trestle. This latter weight does not act like the weight of the water, in a direction away from the center of the curve, but may be assumed to act in a vertical direction. If the trestle be built of sufficient strength to support the maximum load so determined, no transmission of loads through the pipe shell needs to take place, and the section of pipe over one sill, reaching half way in either direction to the nearest sills, will exert no influence upon the adjoining sections.

It may be well to anticipate here an objection that some may raise against the method of reasoning so far followed, in considering bodies of water terminated by planes normal to the axis of the pipe. Supposing the cutting planes be assumed at some arbitrary angle, as in Fig. 10, an apparently different result is obtained.

Fig.10.



The forces P_1 and P_2 substituting the effect of the adjoining water columns, will have a resultant towards O, instead of away from O, and the resulting load upon the pipe may for such a section become less than that caused by the weight alone, instead of more.

As far as the load upon this section of pipe, and the support required for it along $A\ C$ is concerned, this would be actually so, in case the construction of the pipe were such as to cause the upward pressures against $B\ b$ and $D\ d$ to offset part of the downward pressures, not along $a\ A$ and $c\ C$, as in a normally constructed pipe, whether of steel, banded wooden staves or of metal, but along part of $A\ C$. Whilst the load upon the supports along $A\ C$ is thus decreased, this decrease is but the measure of the increase of loads upon the supports along $a\ A$ and $c\ C$, no longer relieved by the upward pressures against $B\ b$ and $D\ d$, this peculiar construction of a section of the pipe thus simply resulting in a redistribution of loads along $a\ c$, but not in any increase or decrease of the total load along $a\ c$ as previously determined. If this arbitrary method of investigation be followed in the case of a normally constructed pipe, and we analyze the exterior forces, acting upon the pipe section $A\ B\ D\ C$, we find that they consist not only of the pressures of the water upon the inside of the pipe, of which the forces P_1 P_2 and W are the equivalent, and the most simple expression, and of the reaction from the support, but also of forces developed in the structure of the pipe in keeping top and bottom of pipe together. For it is evident that the parts of the pipe $a\ A\ B$ and $c\ C\ D$ in a normally constructed pipe must have a decided influence upon the parts $b\ A\ B$ and $d\ C\ D$ respectively, which may be represented by forces Q_1 and Q_2. If these forces be taken into account when the load upon supports along $A\ C$ is calculated, the result will be the same as that obtained by the more simple method of normal sections $A\ b$ and $C\ d$, for which the forces Q become zero.

We will now proceed to apply the formulæ to the case of the 52-inch pipe siphon, for which the data are given in the table below. The sills are spaced along the bottom of the pipe, 36 inches center to center, and we will determine the load upon a sill at the lowest point of the pipe, for which $\beta = 0$, and upon a sill at a point upstream, for which $\beta = 20°$, it being understood that there are thirty-four sills between the two sills considered, which carry loads varying between the limits as calculated.

r = radius of pipe..... = 26 inches.
R = radius of curve = 300 feet..... = 3600 "
L_1 = distance center to center of sills.... = 36 "
L = length of pipe borne by each sill measured along the axis..... = 35.71 "
H_0 = piezometric head for $\beta = 0$..... = 1913 "
H_{20} = " " " $\beta = 20$..... = 1699 "

k = weight of a cubic inch of water..... = 0.0361 pounds.
V = maximum velocity..... = 8.14 ft. per sec.
i = hydraulic slope..... = 0.0025

From this we have

$k \pi r^2$ = weight per lineal inch of water column..... = 76.665 lbs.
$W = k \pi r^2 L$ = weight of water column over each sill..... = 2738 "
$P_\circ = k \pi r^2 H_\circ$..... = 146660 "
$P_{20} = k \pi r^2 H_{20}$..... = 130254 "
$\frac{L}{R}$..... = 0.00992

The central angle of the section over each sill is about 34′ 10″, and the error involved in using formula (11) instead of the complicated formulæ (7) and (8) amounts to less than ½ per cent. Some values entering in the calculation may contain errors as great, and it would therefore be useless to attempt a further refinement than is afforded by the use of the simple formula (11):

$$T = W \cos. \beta + P \frac{L}{R}$$

From which we have

$$T_\circ = W + P_\circ \frac{L}{R} = 2738 + 1455 = 4193 \text{ pounds},$$

and

$$T_{20} = W \cos. 20 + P_{20} \frac{L}{R} = 2573 + 1292 = 3864 \text{ pounds}.$$

Further from formula (12) the centrifugal force

$$E = \frac{W \frac{v^2}{R}}{g \frac{}{12}} = 19 \text{ pounds},$$

all acting away from O and from formula (13), the tangential resistance $K = W i = 7$ pounds.

Finally the weight of the pipe, which at the bottom for $\beta = 0$, amounts to 262 pounds per lineal foot or 780 foot pounds per sill, and for $\beta = 20°$ to 256 pounds per lineal foot or 762 pounds per sill, the difference being due to a different spacing of steel bands. These latter weights may be assumed to act vertically downward.

The forces acting upon each of the sills are shown in Fig. 11, drawn to scale so as to show their relative importance.

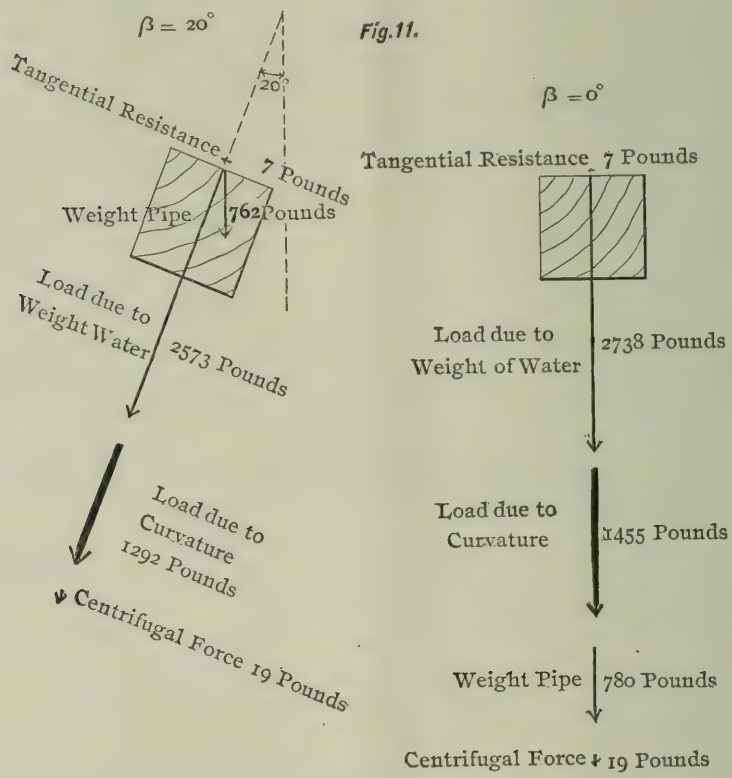


Fig. 11.

It may be added here that the 52-inch inverted siphon, to which the formulæ have been applied, is part of the very interesting and, in many respects, novel works of the Bear Valley Irrigation Co., of Redlands, Cal., designed by our fellow member, Wm. Hammond Hall, the pipe siphons having been built under contract by the Excelsior Wooden Pipe Co., of this City.

Attention has been called to the fact that when the pipe curves in the form of an arch the effect of curvature is in an opposite direction to that of the weight. An interesting instance of this is mentioned in a paper read before the Institution of Civil Engineers (Proceedings 1892—1893, Part III, Paper No. 2724, by E. P. Hill), from which the following is quoted :

" In some cases it is necessary to anchor the bends, as where a pipe rises out of the ground to pass over a bridge. The prudence

of doing this became apparent in several instances on the aqueduct from Thirlmere to Manchester. The straps which surround the bends, and to which the anchor rods were attached, did not always follow truly the surface of the pipe, and a slight space was in some cases observable between the strap and the pipe. When the pipes were charged, however, the inner edge of the strap coincided perfectly with the surface of the pipe, showing that the anchor rods were doing the work for which they had been provided.

To illustrate the magnitude of the forces to be resisted, it may be mentioned that in the cases of the 40-inch pipes used on the Thirlmere aqueduct, the unbalanced thrust at a bend of 34° subjected to an internal pressure of 100 pounds per square inch (and in some instances the pressures were as high as 180 pounds) amounts to nearly 33 tons."

DISCUSSION.

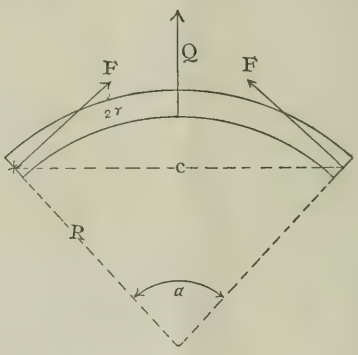
The author, after briefly reviewing the paper read at the previous meeting, adds:

"It has been shown that a resultant thrust exists, wherever a change of direction occurs in a pipe line. As I have heard the opinion expressed, that whilst this may be so for wooden pipe, where the curvature is gradual, no such thrust is noticeable in lines of iron pipe, where the curve is usually produced by angles at the joints, I will quote from the discussion on a paper of Mr. Hamilton Smith, before the American Society of Civil Engineers (Transactions American Society, Feb. 1884). Mr. Smith there describes the North Bloomfield pipe lines, made of sheet iron, joined with slip joints where the pressure does not exceed 300 feet. To the question: 'What keeps the pipes from pulling apart?' he answers: 'There is no danger of this where the pipe has no sharp bends, at bends the pipes must be strongly braced on the outside of the bends.'

I will further quote from a letter recently received from Mr. C. P. Allen, chief engineer of the Citizens' Water Company, at Denver. 'Regarding extra strain on pipe laid on curves, I should consider that there would be as much thrust outward as the difference in exposed surface between the long and short sides of the curve. I know that in putting in cast-iron pipe we have to take great care with all bends, otherwise they will slip apart. I have had this very forcibly impressed on my mind about two years ago when we had a 30-inch 45° bend, 25 feet radius, buckle out. It not only slipped apart but raised its own weight and two lengths of 30-

inch pipe, altogether not less than 7,000 pounds, and also broke a one-inch truss rod on the outside of the bend. There was about 65 pounds pressure at this point. I also had a 20-inch 90° bend slip apart under 100 pounds pressure. This was laid in a ditch five feet deep; and after the pipe was jointed, rock was tamped in on the outside of the bend with heavy tampers. When the pressure was put on the pipe it pushed back into the side of the ditch at least one foot and pulled the joint entirely out.'"

PRESIDENT GRUNSKY.—"The problem discussed by Mr. Henny might well, it seems to me, have been simplified by separating the forces due to pressure of fluid in the pipe from those due to its weight, and expressing in simple formulæ the resulting forces. It may be desirable in any case to know either the aggregate value of such forces, or to express them per lineal unit of pipe. What I have to say applies merely to the forces resulting from a uniform internal pressure, and to the strains resulting from such pressure in the material of which the pipe is constructed, or if the pipe cannot be subjected to longitudinal strains, then to the forces to be resisted by support from without.



$$F = r^2 \, p \, \pi$$

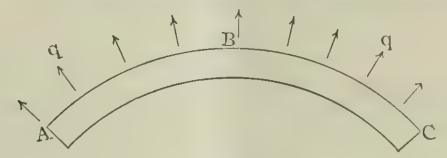
$$Q = 2 \, r^2 \, p \, \pi \sin. \tfrac{1}{2} \, a = \frac{r^2 \, c \, p \, \pi}{R}$$

In this expression Q represents the aggregate outward pressure, R the radius of curvature, p the pressure of the fluid in the pipe, $2\,r$ the diameter of the pipe, and c the chord of the arc subtending the angle a.

The outward pressure for $c = 1$ may be expressed thus:

$$q = \frac{r^2 \, p \, \pi}{R}$$

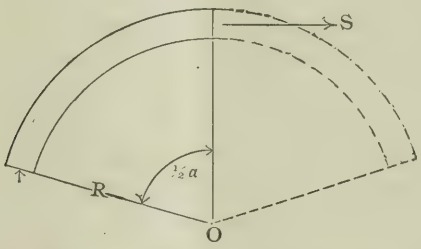
The pipe, which is laid on a curved line, must be constructed in such a way that it will resist the resulting longitudinal strains, or it must receive support from without. Suppose a curved pipe $A\ B\ C$



to be firmly supported from without at A and C, then the bending moment of $\Sigma\, q$ will produce maximum tension in those filaments of the pipe material on the convex surface of the pipe; but if this pipe be supported only at B, and the points A and C be free to move, then the maximum tension will be in the concave surface of the bend.

Aside from the strains due to any bending moment resulting from improper support, there are longitudinal strains in all curved pipes, if constructed of material capable of resisting such strains, which may be expressed as follows:

$$S = r^2\, p\, \pi\, (1 - \text{cos. } \tfrac{1}{2}\, \alpha).$$



This aggregate force is distributed as a tension to the direction of the pipe to its entire circumference, and the strain per unit length of pipe material in the circumference is proportional to distance from the center of curvature Q. Consequently the maximum and minimum tension per unit of circumference:

$$s_{\max.} = \frac{p\, r^2\, \pi}{2\, r\, \pi} \left(\frac{R + r}{R} \right) (1 - \text{cos. } \tfrac{1}{2}\, \alpha)$$

$$= \frac{p\, r}{2} \left(\frac{R + r}{R} \right) (1 - \text{cos. } \tfrac{1}{2}\, \alpha)$$

$$s_{\max.} = \frac{p\, r}{2} \left(\frac{R - r}{R} \right) (1 - \text{cos. } \tfrac{1}{2}\, \alpha).$$

$$\text{For } a = 180°, \quad S = p\, r^2\, \pi.$$
$$\text{For } a = 360°, \quad S = 2\, p\, r^2\, \pi.$$

It is also interesting to note that for $R = r$, and $a = 360°$,

$$s_{\max.} = 2\, p\, r,$$

representing the strain in the direction of the circumference in a pipe having a diameter $= 4\, r$.

By the use of the above simple formulæ, or others that can be readily deduced, all principal forces and strains can ordinarily be determined. This is particularly true in case of horizontal bends, and for water pipes of small diameter and relatively great pressure, also in case of steam and compressed air pipes where weight of fluid need not be considered.

For extreme cases, as presented in the example cited by Mr. Henny, it seems to me that it might be sufficient to apply such corrections as may be due to weight and varying pressure, without having recourse at the outset to a theoretically correct formula.

This is all said merely for the purpose of opening the discussion of the evening, and may be redundant, as I did not hear Mr. Henny's paper read, and have information of its contents only from the explanatory statement made by him this evening."

MR. RULOFSON.—"Mr. President, it seems to me that the problem would be a good deal simpler if the pressure were considered with the pipe lying on a horizontal plane, because then we would have the weight of the water in another direction, and we should get something more than the pressure due to curvature. I would be very much pleased if I could see the illustration carried out, eliminating the weight of water, and considering the pipe as lying on a horizontal plane. That would separate the two forces, and eliminate the force due to weight."

MR. WAGONER.—"As illustration of the care necessary in laying and properly securing pipe lines, I submit the following statement of facts:

Last year I laid about 500 feet of 12-inch riveted slip-joint pipe, the total head at wheel being 235 feet. Each joint was 18 feet long, and the grades of the pipes were as follows: beginning at the water wheel, 0°, 5°, 35°, 25°, 20°. The first four pipes were uncovered, the 20° joint was covered with 4 feet of earth; under the joints 5° —35° there was built a wall of dry rubble masonry, and wooden wedges were driven firmly under the pipe from each side for a dis-

tance of three feet each way from the center of the elbow. The gate was closed, and water turned in the pipe. The pressure opened the joints at each end of the first joint, and raised the 35°—25° joint sufficiently to disconnect the pipe at 0°—5° joint. Anchor bolts and a saddle were put in for the 35°—25° joint, and with much difficulty the pipes were forced back into position.

The immediate cause of the sliding of the pipe appeared to be due to the dip acting as a lubricant, and allowed sliding of the pipe on the wooden wedges. It also appeared to have shortened the pipe by forcing in the elbows. For such cases as quoted above too much care cannot be taken in carefully heating and driving up the joints when laying the pipe, and the enlarging of all elbows whose vertices are upward should not be omitted. I think the foregoing seems to confirm the points set forth in Mr. Henny's interesting paper."

PRESIDENT GRUNSKY.—"I would like to ask if the buckling was in this joint where the angle was from 5° to 35°; whether that did not cause a forward movement, and for that reason the pipe raised at the point indicated? It is a question whether the length that was at an angle of 10° would alone create a pressure sufficient to raise that pipe."

MR. WAGONER.—"I think it would have slid on anything. There might have been some slight settling of the masonry."

PRESIDENT GRUNSKY.—"Was it not due to the larger bend rather than to the smaller one?"

MR. WAGONER.—"I do not think so. There was a pressure of about 11,400 pounds on the pipe forcing it back. It was built on a very solid wall of masonry, well wedged with wooden wedges. There would be no way of anchoring it, as far as I can see, to stop the motion, other than the way I did it."

MR. HENNY.—"As to the argument that my method of treatment is unnecessarily complicated, it must be understood that the object of the paper is not simply to determine the value, but to demonstrate the *existence* of a resultant thrust at the curves of a vertical pipe system, in which the pressures are derived from the weight of the water alone. This, it should be remembered, has been denied by a number of engineers, with whom the subject has been discussed.

In a horizontal pipe system, the aggregates P_1 and P_2 of the pressures supposed to act upon the ends of a curved cylindrical body of water, are equal and independent of the weight of the body. In a vertical pipe system, however, they are not equal, the difference being directly due to the weight of the body. To assume them to

be equal is an approximation, which it may or may not be safe to make at the end, when the error involved may be determined, but which should not be made at the outset, lest the entire conclusions be called into question."

MR. RICHARDS.—"The very frequent rupture of steam pipes under high pressures, which at this day reach 150 to 180 pounds to the square inch, has led to a good deal of investigation in regard to internal pressure of curved pipes. What the latest conclusions are respecting it, I do not know, nor do I know just whatth is has to do with Mr. Henny's proposition, but it seems to me there has not been taken into account all of the strains of internal pressure.

I will make a rough diagram of a Kenyon indicator. The pipe was bent in the form of the letter G. When filled with steam pressure, the tendency was to straighten, producing movement to operate an index that indicated the steam pressure. Now the shape of this pipe was the subject of very long discussions, and the most abstruse mathematical calculations, and of long correspondence in technical journals in Europe, until finally these indicators were made and became a regular article of manufacture.

The rupture of steam pipes generally takes place on the inner curve of the bend. When the ends are free, or where there is a section long enough to permit of lateral movement, there is a tendency to straighten. Whether this is a force that is not taken into account in Mr. Henny's paper I do not know."

PRESIDENT GRUNSKY.—"The difference between the steam pipe and the pipe mentioned by Mr. Henny, it seems to me, would be this: In the steam pipe all strains and forces are taken up by the material itself, and that the resultant is expressed in that change of form; but in the wooden stave pipe, where there is no longitudinal strain, all this must be met by opposite forces."

MR. HENNY.—"The ordinary Bourdon gauge has been considered by me as possibly affording a practical demonstration of the existence of the resultant thrust in bent pipes. If the Bourdon tube had a circular section it would be available for my purpose, but in that case the gauge would be of no more use for the purpose of registering pressures than a straight tube, the very small longitudinal stretch being the only cause of motion of the unsupported end.

A similar statement was made by Mr. A. F. Nagle, in a recent issue of the *American Machinist*, which led to an experiment, of which Mr. A. Bement, in a later issue of the same journal, gives the following account: 'A circular tube 17½ inches in length, $\frac{5}{16}$ inch

in diameter, and $\frac{1}{32}$ inch thick, was bent into the arc of a circle 7 inches in diameter. But this tube did not straighten even when subjected to a pressure of 1,000 pounds to the square inch, although an elliptical tube formed with such distribution of metal would have been sensitive to small changes of pressures.' The pressure upon the closed unsupported end of the circular tube tends to close the curve to which it is bent, and is kept in balance by the resultant thrust, which tends to open it. The fact that no movement could be recorded, although the pressure upon the closed end, under 1,000 pounds pressure, must have been nearly 77 pounds, demonstrates in a negative manner the existence of the resultant thrust, which forms the subject of my paper.

The tube in the Bourdon gauge is of elliptical or approximately elliptical section, its action being entirely dependent upon the tendency of the interior pressure to cause the section to assume a circular form. In so doing the relative position of the sides of the tube turned towards and away from the center of curvature changes, and with it the radius of curvature changes, thus causing movement of the unsupported end of the tube, according to well-established principles. Whether or not a Bourdon spring is employed in a Kenyon indicator I do not know, as I am not familiar with the instrument, but I would judge so from Mr. Richards' description."

MR. D'ERLACH.—"This idea has been troubling me also, and I have tried to demonstrate it to myself, I do not know whether I have succeeded or not. We have a curved pipe here supposed to be closed at the ends, and under pressure. Now I want to find the strain the material is put to in this central section. That strain will be in the direction perpendicular to the section, and, as Mr. Henny says: 'The projection will be that of the section in the direction of the force.'"

MR. A. D. FOOTE.—"I want to mention a fact that hydraulic miners have learned from sad experience. When the miners began to put in hydraulic pipes for washing dirt, they ran them down hill straight. They found that occasionally the pipe would become emptied of water for some cause, and the pipe would expand; when the water came in again it would contract. Then they made curves, so that when the pipe got warm it increased the curve rather than shoved the pipe together, and when it cooled it would flatten the curve instead of pulling apart. That answered the purpose very well, but they found very quickly that it was also necessary to put

posts down along the outside of the curves to support the pipe and keep it in place.

It was also found that with the pipe laid to curves in the way described, the water would be set rotating in the pipe, so that when coming out of the nozzle it would be whirling, and would not wash, as desired. To overcome this, two pieces of thin sheet iron, crossing each other at right angles, were placed in the pipe, ten or twelve feet above the nozzle, which stopped the whirling of the water."

NOTE ON THE DUTY OF THE CALIFORNIA WET-CRUSHING STAMP MILL.

By Luther Wagoner, Mem. Tech. Soc.

[Presented October 6th, 1893.]

An examination of the tabulated statement of facts concerning all the stamp mills, as given in the Eighth Annual Report of the State Mineralogist (California), pages 692 to 695, shows that the output of any mill can be closely approximated to by taking the product of three factors deduced from the data given, as follows:

The foot pounds of work done by the falling stamp;

The $\frac{2}{3}$ power of the screen aperture;*

A coefficient of hardness.

NOTATION.

W = weight of the falling stamp in pounds.

D = drop of the falling stamp in inches.

N = number of drops of stamp per minute.

A = width of aperture in screen in inches.

T = tons crushed per stamp per 24 hours.

K = coefficient of hardness, and for which the following values are suggested:

$K = 13$ for very hard and tough quartz.

$K = 16$ for hard and tough quartz.

$K = 22.7$, the average of all the quartz crushed.

$K = 30$ for soft quartz with clay, etc.

$K = 40$ for rotten quartz with clay, etc.

$K = 50$ for soft talcose slate, and rotten quartz with gouge.

Then:

$$T = \frac{K.\ W.\ D.\ N.\ A^{\frac{2}{3}}}{1{,}000{,}000}$$

The above formula is to be used for slot-punched screens.

Taking $W = 900$, $D = 6$, $N = 90$, $K = 22.7$, the following values of T are found for the different screens:

No. 4 screen,	$T = 2.85$	No. 8 screen,	$T = 2.43$
No. 6 "	$T = 2.65$	No. 10 "	$T = 2.20$

*The crushing power per foot pound of work is inversely as the screen aperture, while the discharge must increase with the aperture from the first to the second power, depending upon the form; hence $T = f\ A^{-1}\ f\ A^{1\text{ to }2} = f\ A^{\frac{1}{2}+}$; $\frac{2}{3}$ is adopted for the exponent as more nearly according with data mentioned, and for slot-punched screens. $\frac{3}{5}$ is the value of exponent found for some dry crushing work with wire-cloth screens.

REGULAR MEETING, NOVEMBER 3, 1893.

PROCEEDINGS.

MINUTES.

The meeting was called to order at 8:30 P. M., by the President.

The minutes of the last regular meeting were read and approved.

Mr. F. E. Trask, of Ontario, was elected to membership.

The following propositions were read and referred to the Executive Committee—

For Member:

H. Clay Kellogg, Hydraulic Engineer, of Anaheim, California; proposed by D. C. Henny, Geo. F. Schild and Wm. C. Alberger.

For Associate:

Samuel C. Irving, of San Francisco; proposed by A. d'Erlach, H. C. Behr and Otto von Geldern.

Mr. D. C. Henny, the Society's delegate to the recent Irrigation Congress, submitted the following report:

TO THE TECHNICAL SOCIETY OF THE PACIFIC COAST:

Your delegate to the International Irrigation Congress, held at Los Angeles, Cal., from Oct. 10 to Oct. 14, 1893, begs to report as follows:

The proceedings of the Congress were interesting in many respects. Technical papers were read by—

F. H. Newell, on "Irrigation Investigation of the U. S. Geological Survey;"

Don José Ramon Ybarrola, on "Irrigation and Other Public Works in Mexico;"

L. W. Allingham, on "Sun Heat as a Source of Power for Irrigation Purposes;"

C. Comodzinsky, on "Irrigation and Drainage in the Russian Empire;"

C. R. Rockwood, on "Some Mistakes in the Development of Irrigation Enterprises;" also on "Irrigation of the Colorado Desert;"

Robert Stanton, on "The Cañon of the Colorado;"

Leon Phillippe, on "Irrigation in France;"

A. P. Davis, on "Economy in the Use of Water."

Considering the method of electing delegates, the number of engineers accredited to the Congress was large, and it is a significant fact that all delegates from foreign countries were engineers. Each of the States represented, selected one vice-president and one member on the Committee on Resolutions, and after a motion to that effect was carried, the members of the American Society of Irrigation Engineers, and the delegates from Engineering Societies, selected an additional vice-president and member of the Committee on Resolutions. Jas. D. Schuyler serving in the former, and Wm. Hammond Hall in the latter capacity.

One of the most striking speeches made at the Congress, and which called forth no small amount of controversy, was that of J. W. Powell, of the Interior Department of the United States, which is herewith inserted, as reported next day in the *Los Angeles Times*.

"He said he had grown to be an old man while seeing the wonderful development of the country. He was not so much interested in the great railways and extensive public works, valuable as they were, as he was in the development of a great number of homes for the people. He was more interested in the home and in the cradle than in the bank counter.

The water that fell on the land, a large extent being considered, fell unevenly. In some places there was a great maximum, while in others a minimum. In the valley of the Potomac there was an annual rainfall of forty inches. About half of this was re-evaporated and the remainder was carried off by the streams and rivers into the sea. As one came westward there was a lesser proportion carried into the streams in a constantly decreasing ratio, as the stream was considered. In a large portion of the plains the local 'run off,' as it was called, was sufficient to irrigate if it were only stored at the proper places. There was but a small part of the irrigable land that could be irrigated if all the water that could be were used for such purposes. If all the water needed were utilized for the lands now belonging to private individuals there would be none left to use for the lands belonging to the Government.

The lands remaining in the hands of the Government were valuable for stock-raising, for mining and for forestry. In his judgment there should be no more of the Government lands used for irrigation purposes, except in a comparatively few places.

He said in reference to the lack of water, that he believed when the number of inches of annual rainfall per acre in the great arid region was compared with the amount of water needed per acre for irrigation, his statement would be found to be true.

Colonel Hinton of New Mexico said that such statements as these, coming from a man holding the official authority that Major Powell did, and going out to all the world through the points of the pencils (indicating the reporters) meant a black eye to irrigation.

Major Powell, in continuing, said that from a local standpoint there was enough water for irrigation, but making the statement a general one, he felt that he was right in stating that there was, in the arid region of the country as a whole, only enough water to irrigate the lands at present owned by private individuals, without extending the irrigation to the lands now owned by the Government. He said he considered carefully as to whether or not he should make such a statement at this Congress. He felt, however, that it was his duty to do so, for if further Government lands were ceded to private individuals for irrigation purposes there would then not be water enough to go around, and an endless heritage of litigation would be the result."

The Congress finished its work by adopting a platform, in the shape of an address to the people of the United States, in which attention is called to the over-shadowing importance of irrigation to the West. The salient features of the address are in respect to cession of the public domain in the arid region to the individual States, and the thorough indorsing of the California Wright Act as a wise step in the direction of public ownership of irrigation works. The framing of National laws is urged to prevent disputes between States regarding the right to water, and all States in the arid region are advised to make provision for departments of irrigation, supervision and engineering.

In addition to this platform, a number of resolutions were adopted, of which the following may be of interest:

"We advise each State which embraces any part of the arid domain, and which has not already provided for irrigation, supervision and engineering, to do so at its next legislative session, and to vigorously prosecute the work of investigating the extent to which further irrigation can be carried on with success and profit."

After the final adjournment of the Congress, the California delegation met, and decided upon the organization of a State Irrigation Association, and the early assembling of a State Convention, to which it was voted that each county should be empowered to send two delegates, and each irrigation district, irrigation company, university, and the Technical Society of the Pacific Coast, one delegate. The completion of details and the arrangements for a convention were left in the hands of an executive committee.

The proceedings of the Congress will be printed in full at an

early date, and your delegate has made a request for a number of copies to be sent to this Society. Respectfully,

D. C. HENNY.

A discussion was then opened on the subject of Mr. Henny's paper, read at the last regular meeting, entitled "Supports Required for Curves in Pressure Pipes." The author explained the proposition to the members, and the President began the discussion by a general treatment of the subject, after which a number of the members participated. The paper and discussion are published in full in this number of the "Transactions."

The President introduced to the Society, Mr. Arthur D. Foote, Civil Engineer, as guest of the evening.

Adjourned. OTTO VON GELDERN, *Sec'y.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME X. No. 11.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

IMPRESSIONS OF A MECHANICAL ENGINEER AT THE WORLD'S COLUMBIAN EXPOSITION.

BY GEO. W. DICKIE, Mem. Tech. Soc.

[Read Dec. 1st, 1893.]

During the passed two years or so, all the great channels, as well as the little streams, that carry the thoughts of writers to the reading millions, have been swollen to flood height by World's Fair literature, presenting to the public mind and eye the great Chicago Exposition.

The best writers of the day, assisted by the best artistic skill and the wonderful development of the printer's art, have combined to make the White City by the Great Lake familiar to many millions who either had not the time or had not the means to make a personal acquaintance with this mighty assemblage of nineteenth century industry and art.

In endeavoring to give you in a simple way the impressions I received as a mechanical engineer seeking for new inspiration in his own field of engineering, it will be understood that I do not wish to speak for the mechanical engineer as a class, but only for myself. This privilege being granted, my task will be a simple one, as it will not be necessary to consult authorities or quote the opinions of others.

The principal attraction drawing me to Chicago during the hot month of August, was the Engineering Congress held during the first week of that month in the Memorial Art Palace. My impressions of the Congress will, therefore, be first in order, and as I am to speak only for myself, these impressions will apply only to the section in which they were received — that of marine and naval engineering, except a few thoughts suggested by the formal opening and closing meetings, attended by all sections.

My first impression on entering the Hall of Washington at the opening session, was that of astonishment at the number of eminent men in our busy profession who had found time to come from all parts of the world to attend these meetings ; and then the spirit in which the opening addresses were given by those representing the great engineering societies, was an intimation that no one expected to be a teacher there, but that all had come together to learn things that they had not known before, from the experience of others. I was thankful indeed to be a unit in such a gathering, and also to find that although we, in San Francisco, are far removed from the great centers of engineering enterprise, our work is known and appreciated by the leading engineers, especially of Europe.

As a member of the American Society of Mechanical Engineers, my place naturally would have been in Section B, had not Commodore Melville, the present Engineer-in-Chief of the United States Navy and chairman of Section G, enlisted me to work for his section. This was fortunate for me, if not so for this section of the Congress.

There being at that time no organized society in this country especially devoted to marine engineering and naval architecture, gave to the deliberations of this section a wider scope than would have been possible if restricted to the usual society proceedings; and the fact that the work done at the meetings held by this section is to be published and sold on its merits, brought out the best efforts of the best men in the profession.

The proceedings were enriched by papers from such prominent men as, Sir Nathaniel Barnaby, Dr. Francis Elgar, Albert E. Seaton, Casimiro De Bona, B. F. Isherwood, Prof. W. Riehn, Nelson Foley, Nabor Soliani, James Howden, Henry Renbow, J. Harvard Biles, Archibald Denny, and many others.

I had some fear that my boldness in presenting a paper giving my views on certain matters connected with war ships, and my presence in such a gathering, could only result in a humiliating

sense of my own littleness in such an assembly. This fear, however, was very soon dissipated. These men who had been doing so much for the advancement of a great art, were pleased to listen to the experience of one who had been trying to work out some problems in a far-off, out-of-the-way corner on the Pacific. This willingness of those who were leading in the great centers of engineering activity, to discuss with and profit by the experience of those who were working out the same problems, but under vastly different conditions, impressed me with a sense of the value of such meetings. To me it was very encouraging to think that the labor I had often thought was thrown away and little appreciated where it was expended, was not all in vain, but had its effect and produced results where the laborer thought himself entirely unknown.

The one thing that impressed me most during the meetings of our section of this great Congress, was the way in which the subjects treated of in the various papers would broaden out and assume dimensions under discussion far beyond the scope of the original paper. The ideas expressed in a paper produced in a British seaport, when discussed by a marine engineer or ship-builder whose experience was limited to the practice on the Great Lakes or rivers of North America, had to meet conditions and be compared with results that were not only new, but in many cases very startling to the author.

One day during the discussion of a paper on river steam-boat practice, I was endeavoring to point out the advantage of compounding stern-wheel engines, recommending tandem compounds on each side, either condensing or non-condensing, when the author of the paper remarked that first cost was the most important consideration in the construction of a western river steam-boat; efficiency or durability being of secondary importance. "But," said I, "the every-day expense of running must be an important matter, especially where transportation was effected so cheaply." "Why," said he, "I am afraid that the gentleman from the Pacific Coast has had but a small experience with western river practice. As an example of economy let me give you an instance of a freight stern-wheeler in my district that made her daily runs for the last season of eight months on a total expense of $2.25 for fuel, and this expense was caused by the carelessness of the crew one night not securing wood enough for the next day's run, necessitating the Captain's buying enough to last until dark, as his method of taking on fuel would not work in daylight. In this case what would be the advantage of compounding?"

We had not considered the subject from this standpoint, and had to admit that such conditions would not justify more expensive engines to save fuel.

This meeting of marine and naval engineers at Chicago was to my mind a most remarkable gathering, as being held far from the seaboard, yet on the shore of one of the mighty fresh water oceans of this continent. These men from Europe full of the problems involved in building ocean greyhounds or mighty battle-ships, met men that were solving the transportation problems of the Great Lakes. For the first time the magnitude of these problems and the skill that had solved them would receive attention from those who had been too busy with their own schemes to give any thought to what was going on in the heart of this continent, and I venture to say that this meeting together of ocean and lake practice in ship-building will have its effect and the result will appear in modified types of naval architecture, both on ocean and lake.

The general closing meeting of the Congress was very interesting. The chairman of each section gave a short account of what had been done in his division; and the representatives of foreign societies told us what they were going to say about us and the things we do when they get home. And so we parted after a week of honest work for the good of the profession.

During the Congress I had devoted but little time or thought to the Exposition, beyond spending the evenings inside the grounds, and I must say that these evenings have left in my mind the best impressions I have retained of this wonderful aggregation of human art and industry. On the electric launches inside or on the steam launches outside, sights were obtained that have left a lasting impression, and produced effects on men's minds that cannot fail in modifying thought and stirring into life a more general desire for more artistic surroundings, both in public and private enterprises, than have hitherto prevailed in this country. My first thoughts were that much money and art labor had been wasted on what at best were but temporary coverings for exhibits, and that the impression produced would soon vanish like that of a dream. These first thoughts soon began to take on the modifications that come with more mature reflection, until the impression finally settled into my mind and there remains, that the Columbian Exposition was an inspiration born of a great necessity to rouse the American soul out of the dead level of utilitarianism and breathe into that soul a love of the beautiful. No one could look into the faces of the many

thousands of homely American men and women, not representing the wealth and beauty of this great republic, but the brawn and muscle from her fields and factories, and not be impressed with the fact that new ideas and higher aims were beginning to take shape there. This exhibition of beauty in form and richness in art, will have a lasting effect in the minds of the great masses of this country. A love of the beautiful and the true in form has been implanted in the hearts of many thousands throughout that portion of this country where it was most needed. The humble homes throughout the land will feel the touch of that influence and a regeneration will be the result that I trust may reach things mechanical as well as things architectural. That the mechanical mind of the present day has successfully divested itself of all sense of the beautiful, is abundantly proven by the fact that so many hideous mechanical contrivances were exhibited within these beautiful structures.

As the impressions I am trying to describe are those of a mechanical engineer, the best place to receive these impressions was the Machinery Hall, and so for the first two or three days I devoted the working hours to the contents of that great and beautiful building.

In making a general tour through this vast assemblage of driving and driven machines, I was first impressed with the hopelessness of trying to make any intelligent, systematic study of any type of engine or machine exhibited. This was largely due to the method of arrangement that had been adopted. Exhibits were grouped in the spaces assigned to the various countries which produced them instead of being grouped in the classes or types to which they belonged. This, to me, was very perplexing, it being impossible to compare the merits of any one exhibit with a similar exhibit of the same class but of a different country.

I endeavored one day to reach some decided opinion as to the merits of the various examples of vertical engines adopted for driving electric generators direct, but found that after taking a mental inventory of the good points in one set of engines, the photograph that I had tried to carry in my mind to a remote corner of the building where another such set of engines could be found, was by reason of the many intervening things demanding attention, completely obliterated. I had, therefore, to abandon any attempt at comparison between exhibits and simply wander around, noting only such exhibits as at first sight produced a very good or a very bad impression, and, striking a balance, arrive at a general impression of the whole. The result I am sorry to say, was disappointing.

Here the electro-mechanical engineer had it all his own way, but this splendid opportunity was allowed to pass by unimproved of establishing by a practical demonstration under what conditions it is economical to convert mechanical energy into electrical energy, and carry it by conductors to the various machines of a factory, and there convert it back again by means of electric motors into mechanical energy.

When I tried to compare the number and power of engines driving generators with the number and size of machines driven by electric motors, there appeared to me to be an immense loss of energy somewhere, and it was disappointing to find no means to prove whether the impression produced was true or false.

The steam engine exhibits at Chicago confirmed an impression that for years has been forming in my mind, that the prime mover which has done so much for the advance of civilization and material wealth is not now held in the same veneration as in years gone by. Designers, builders and owners now treat the steam engine no better than they would a lathe, a planing machine, a loom, or a printing-press. Democratic ideas at present prevail in mechanics, the declaration has gone forth that all machines are equal, and by right are free to perform their functions with the least possible expenditure of material carefully disposed in the direct lines of strain, no matter how offensive these unclothed skeletons may be to those who remember the time when the steam engine was the master machine, had a splendid house or palace for its own use, had a dignity of its own apart from and above the factory to which it imparted life and motion, and when its owner died or gave up business the great engine went as part of the land and buildings, and not as a mere manufacturer's implement.

I looked in vain for some trace of the dignity of form and proportion and the grace of motion that characterized the factory engine of twenty years ago; the massive finely moulded base; the correctly proportioned columns and rich entablature, with the cylinder or cylinders so encased in polished mahogany as to be in harmony with the other statical parts of the structure, and all this, filled in with the artistic tracery of parallel motion and connections, making a complete machine that gave satisfaction to the soul of a true mechanic. With what is modern mechanical science, hampered by the all prevailing desire for something cheap to serve a present purpose, replacing these stately monuments of mechanical genius?

Here is what I found as the modern development of mechani-

cal science. A square box called the high pressure cylinder, close behind it a larger square box called the low pressure cylinder, and usually a round box on top with a leg in each of the other boxes called the receiver. Between these boxes and the shaft journal in the line of tension and compression strains, either steel rods or straight castings are fitted of just such form and dimensions as will resist the strains produced when the thing works.

Now these lines may be perfectly correct and just the proper amount of material may be disposed around them, but I claim this to be an indecent exposure of the design. The disgusting nudity of these miserable machines, is not the nude in art as we find it in the Art Building, but rather naked skeletons of the anthropological exhibit. This setting up of the bones of a design as a finished result, denoting the presence of science without art in mechanics, produced on me a most painful impression, which deepened into actual shame that our profession had made such an unworthy exhibition of its own decadence.

I am often told that the useful only should be retained in any design. That is true, but who can say what is useful? Your best poet says:

> "Nothing useless is or low,
> Each thing in its place is best;
> And what seems but idle show
> Strengthens and supports the rest."

What would the beautiful building be that shelters these miserable mechanical skeletons without its clothing of staff? What hideous spectres would have surrounded the Court of Honor, if only the actually useful had been allowed a place? In regard to our other surroundings, we are not satisfied with the bare necessities of existence, and why should we be so in mechanics?

One of the conditions resulting from this utilitarianism is the sameness of design by all makers of certain types of engines. They could only be identified by the name plates, and were entirely without character, and are to mechanical art what a chromo is to a painting.

This condition is very distressing when we come to follow these mechanical contrivances to the permanent positions they are to occupy in factories or power stations throughout the country.

I must say, however, that in the various Eastern power stations that I visited, the engine designs as a rule were far more satisfactory than those exhibited at Chicago. In giving you the general impressions

produced on my mind by the steam engines exhibited, I must make one or two exceptions, notably a set of vertical engines for driving electric generators exhibited by a German firm, the satisfactory proportions of which did much to relieve the distress produced by the American horizontals. It seems to me that the modern idea as to form in mechanics is limited to what a planing machine can produce in flats, and a self-acting slide rest lathe can produce in rounds.

In my younger days when material not essential to the working of the machine had to be filled in between two points, the instructions given on the drawing were to make the part eye sweet, thus leaving something for the artistic character of the workmen to develop, and I know from experience how these little opportunities were improved by the true mechanic.

Before leaving the matter of engine design as displayed in the exhibits at Chicago, I desire to call attention to the prevailing indifference manifested by engine builders, and those who employ them, as to whether their designs are in keeping with their surroundings.

While East I visited a great many power stations, and in no case could I trace any relationship between the engines and the structures that sheltered them; in fact, as a rule, the designs were entirely opposed to each other, In one city I found a very pretty Gothic building sheltering a very ordinary horizontal pumping engine. The house was a thing of beauty, displaying true artistic skill in its design. The machine it sheltered was — well I hope for the sake of my profession that it was bought in some machine junk shop, and not designed for the place it occupies.

In another city I was driven to the water works, and on seeing the buildings my hopes ran high, expecting for this once I would find that a master had been there. The engine house was a castellated structure of rough hewn stone, in the Baronial style, the water tower being encased in the same style of stone work with a castellated top like the engine house, and the bronze railings and gates, with their battle-axe terminals, were all in keeping with each other. But with the architect all this unity of design ceased. Within I found two beam pumping engines, very well designed in themselves, but it just occurred to me that the owner of this Norman castle had gone down to Greece and stolen the engines out of some Ionic temple. Another set of engines, in the same building, were of the horizontal fly-wheel type, without any character whatever. Evidently the first two sets of engines were special designs, and if

the designer knew where they were going, and in what kind of a structure they were to pass their lives, why did he not design them so that they would be at home there? What a splendid opportunity to mount a beam on a Norman tower, supported on a rough hewn base, with loop holes for the foundation bolts!

The horizontal things had no business there at all, and as they were new, they only served to show how far we have fallen away from all appreciation of what is good in design.

Coming back again to the Exhibition and to Machinery Hall, I am glad to say that the impressions I received from a general and hasty observation of the varied and extensive display of machines in general, was on the whole much more satisfactory than my impressions relative to prime movers. Machine tools and machines for the various manufacturing operations show, I think, a steady advance, both in design and adaptability to the work. In the Krupp exhibit, which is an annex of Machinery Hall, apart from the fine ordnance shown, there were splendid specimens of smith work and machine tool finish. Perfect workmanship is the aim of this great firm, and I know from personal experience that they come very close to it.

The Railroad Exhibit in and annexed to the Transportation Building was, in my opinion, the most important display made at that great exhibit. The arrangement of exhibits was very satisfactory, and the historical grouping enabled the student to trace the process of development that has resulted in the present speed and luxury of railroad travel. In design the locomotive has steadily improved. It is a more sightly machine to-day than it was several years ago. Correct form and well balanced proportions are depended upon now to gain respect for the machine at the front of a railroad train, instead of the bright brass rings and gaudy paint, which characterized the railroadster of twenty years ago.

Compounding the locomotive is gaining favor, if one may judge from the number of this type that were shown in the Transportation Building.

In passenger coaches the utilitarian ideas that I noticed as so all-pervading in engine design, had no place in those exhibited at Chicago. With utility was combined beauty of outline and artistic finish in a very high degree.

The display of models by the great ocean transportation companies and ship-builders, especially those from Great Britain, was not only fine and very expensive, but also exceedingly interesting and instructive. Here the student of naval architecture could trace the

progress of his art from the time when man first "went down to the sea in ships" and did "business in great waters," to this day, when the phantom of steam propels our ships whether the phantom of wind is with us or against us.

Progress in ship-building and marine engineering has been rapid during the past twenty years; and if the universal desire for things cheap, which affects transportation as it does everything else, does not paralyze the efforts of those who are ready to go on to greater achievements, we may look for grander results.

The Transportation Building, with its contents, was to my mind an ideal exhibit, and had there been nothing else at Chicago it would have been a great exhibition.

It is not my purpose to attempt giving the impressions produced on my mind by the displays that attracted my attention in the various exhibition buildings; in fact I have already given you the impressions that I desired to convey in this short address. The Chicago Exhibition was too large, and I trust that in this respect it will never be equaled.

I made several attempts to take in the contents of the Electricity Building. Electric science in its many applications to mechanical work is but a youth, and at present I think is sowing its wild oats. When it reaches the years of discretion it will, no doubt, admit the folly of many things that it now thinks there is great fun in doing. There were many fine exhibits in this building, but, as I have said, the electrician is young, and in some respects just a little foolish. The material he works with is full of tricks and lends itself readily to the show business, and so the Electric Exhibit was largely spectacular, which to the crowd was very grand, but to the mechanic, seeking for new applications of the subtle fluid in transmitting energy to the various mechanical operations he has to deal with, less show and more of real work would have been better appreciated by him. But in this I may be mistaken. Certainly no mechanic could have helped being impressed with the wonderful advance that has been made in a very short time in the science of electro-mechanics. Nothing in the history of human progress equals the rapid advance made in the application of electric energy to all the activities of modern life. In the production of electric energy and its utilization lies the richest field for cultivation by the mechanic of to-day. It is the most elegant agent for the transmission of power that science has presented him with, and I have some hopes that through this agent a revival of artistic taste may be looked for in the product of mechanical engineering.

There was one exhibit that impressed me more favorably than anything that attracted my attention at the Exhibition. That was the Swedish National Exhibit. Within that modest building there was grouped more of what I considered real mechanical art than in any of the other exhibits that made more pretense. In iron and steel, and pottery work, this exhibit was a demonstration to me that there was at least one place where the master-mechanic's hand and designer's pencil had not yet lost their cunning. The work was full of character, showing that the smith had hammered some of his own soul into his forging, and the finisher left something of his own refined character on the surface of the metal.

Elsewhere it seemed to me that I had been wandering around in a mechanical wilderness, the machines being as like each other as the clumps of sage brush ; but here, in this little bit of Sweden, it was like leaving the wilderness for a trim little flower garden, where each flower was trained for the best there was in its own individual self; the true workman doing his work lovingly and putting his own self into the product of his hands and brain.

This is the quality that we lack in our mechanical work, resulting in a sameness without character, able enough, perhaps, to do the work for which it was designed, yet without any characteristic feature to command the attention and respect of the beholder.

One of the saddest things I heard at the Engineering Congress was a remark made by the chairman of the section representing the American Society of Mechanical Engineers, in which he held that the day for mistakes being made by mechanical engineers had gone by; technical education had given the mechanic the means to calculate the result required and the means to reach it, and that now improved automatic machines produce the valve gears of steam engines in interchangeable form, so that any engineering concern can buy from a valve gear factory the wherewithall to make his engine run with the best. And so we find the cow running around with a horse's tail, and pretending on that account to be a horse.

Not long ago the town of Dumbarton, Scotland, erected a monument to Robert Napier, the engineer who had done so much to introduce steam for ship propulsion, and nothing better could be found to represent this man and his work than the first steam-ship engine he built. So the old engine has been mounted on a granite base, as a fit monument to the man who had taste as well as skill as a mechanic.

How would the engines we are now designing and building do for monuments to show to future mechanics the evolution of the steam engine ?

DISCUSSION.

PRESIDENT GRUNSKY.—"We have been delightfully entertained by the glimpse Mr. Dickie has given us of Chicago, particularly of the machinery there, and we would be pleased now to hear from any member of the Society who is willing to open the discussion that I am sure Mr. Dickie will further participate in."

MR. RICHARDS.—"I will venture to say a few words to open the discussion. I am hardly able to 'absorb' the æsthetic part of Mr. Dickie's remarks. His criticisms in the main are just, and I will confine the little I have to say to the most salient part of his paper, the modern steam engine in the United States and elsewhere, where the high-speed designs have been carried. I think his criticism in regard to these are correct. Under utilitarian ideas modern high-speed engines have been given an uncouth skeleton appearance. The first tendency in that direction was when our great and honored designer, Mr. Corliss, set his steam engine up on 'legs.' That new departure went all over the world, a great compliment to him. I am not speaking of his valve motion and steam distribution, but of the frames of his engines.

This disregard as to the symmetry of steam engines has always seemed to me to be wrong, and not in good taste, and I hope some day it will pass away. Formerly the foundation and frame were made parts of one structure, such designs were graceful and attractive to look at. But when engines are set up on 'legs' they are the opposite. In one of the electric-lighting stations here we have a large engine of 500 or 600 horse-power that was made in Milwaukee, one of the utilitarian kind, almost without a frame; people go around it and do not want to see it.

It is not altogether a money matter or a saving of material. Everything connected with an engine should harmonize. Some of the highest types of steam engines in the world can be found among our own, such as are used in some of the large manufacturing mills. In the cotton mills in Great Britain, also, the best types of engines are used. The designs of Sulzer Bros., of Winterthur are excellent; so, also, are those of some Continental makers in Germany and Belgium, but these are not the 'skeleton' type.

The adaptation for electric generators in this country has called forth a type of engine in which regulation was the first consideration, and the next high speed, and there being considerable competi-

tion in this direction in the way of price, the frames in many cases have been made in an unnecessarily uncouth form.

Mr. Dickie's criticisms of machinery shown in Chicago are severe, but I think just; but, unfortunately, a great many of our largest and best makers of machinery in the United States were not represented there at all. Two principal machine making firms, those most capable of making a proper display in Chicago, did not appear there at all. I allude to Bement, Miles & Co., and Wm. Sellers & Co., of Philadelphia.

Among the high-speed engines, one possessing the most celebrity, and which would, no doubt, have been awarded a first prize, is the straight-line engine of Prof. John E. Sweet. This engine is a study; like all he has made, it has marked peculiarities. It was not exhibited at Chicago, and I am afraid it was not there because of some unfair influences being set at work to prevent it being exhibited.

The principal maker of woodwork machinery in the United States, I don't mean the largest maker, but the one who does the best work, and the only one who could have made the best display of good fitting, sent no machinery to this Exhibition. He exhibited in Paris at the first and third Exhibitions there, and was awarded gold medals by the French Government. He exhibited his machinery at Vienna, and received a gold medal there. He has taken his machinery all over the world, and has constructed no less than two or three hundred machines for special use abroad, of which I have personal knowledge, all of the highest class.

There are some machines of his in the Union Iron Works in this City. I allude to Baxter D. Whitney, who of all others, could have best sustained the high character of our wood-cutting machinery at the Exhibition.

Perhaps I had better state the reason, as long as I am reflecting on the management. He prepared an exhibit at a great deal of expense. The drawings and the plans were all arranged, and after some time had elapsed he was informed that he could have "thirty feet square" in which to set up his machinery. Of course he did not set it up. Prof. Sweet was treated in the same manner.

So we must make allowance for Mr. Dickie's criticisms by considering things that were not at the Exhibition. My old firm in Philadelphia, makers of a certain class of machine tools for wood and iron, of the heavier class, had nothing in Chicago that I have heard of. So the exhibit of engines there may not have been representative of practice in this country."

Mr. Bestor.—"While I was at the Great Fair, I had but a short time to spend amongst the machinery, but I noticed that want of art in the design of the machines, to which Mr. Dickie alludes. I expected to see some of the best machines the world produced. They all looked to me like machine goods.

There appear to be two periods of art work; the first is that which is constructed by hand, which you may select from every form. When machines come in, the work looks crude and stiff, and very much alike. As machines are improved, the work they produce is correspondingly better and more artistic. It seemed to me as if the exhibited machinery was in the first stage of machine-made articles.

Mr. Dickie's views are very much the same as my own, in so far as the subjects treated."

REGULAR MEETING, DECEMBER 1, 1893.

PROCEEDINGS.

MINUTES.

Called to order at 8:30 P. M. by President Grunsky.

Reading of the minutes dispensed with.

The following gentlemen were elected to membership:

Member:

H. Clay Kellog, Hydraulic Engineer.....of Anaheim.

Associate:

Samuel C. Irving,.....of San Francisco.

The following applications were read and referred to the Executive Committee:

For Members:

A. H. Koebig, Civil Engineer, San Bernardino; proposed by D. C. Henny, Adolph Lietz and J. H. Striedinger.

E. H. Merrill, Technologist, San Francisco; proposed by Wm. A Doble, John Richards and Frank Soulé.

Mr. Geo. W. Dickie read a paper entitled "Impressions of a Mechanical Engineer at the World's Columbian Exposition," which was discussed by a number of prominent members.

In accordance with Section 2, Article II, of the By-Laws, a nominating committee was duly elected, who shall prepare and present to the Society at the next regular meeting a ticket, naming one candidate for each office to be filled for the ensuing year. The committee consists of the following members:

Ross E. Browne, Hermann Kower,
Marsden Manson, J. H. Striedinger,
H. C. Behr.

Mr. Manson then addressed the Society as follows:

"There seems to be a disposition on this Coast to be indifferent and to tear down anything new in the way of enterprise, or any innovation upon old methods. I do not know exactly why this is,

but it is something that needs to be corrected. I believe that in a few weeks there will come in through the Golden Gate the finest built, the fastest, and the best cruiser on the face of the earth. It is the product of enterprise, skill, clear judgment, and high-class work. In view of all this we sit still and leave to the newspapers the task of spreading abroad to the world what has been accomplished, and it goes out as a matter of newspaper puff, there is no solid and substantial recognition of it by our own people. We should grasp the hands of these men who built this ship and congratulate them. Our citizens should call a meeting for the purpose of expressing their approval. We do not take enough interest in these achievements, we allow the matter to pass without paying any particular attention to it. I would like to see this community give the builders of that ship a reception. I am going to bring it before the Mechanic's Institute, and I believe they will take the initial move. I want to see them congratulate not only Mr. Scott and Mr. Dickie, and the leading men of that firm, but I desire to see them express their appreciation to every man and boy that scraped rivets, and has been connected with that work. I suggest that in case the Mechanic's Institute takes the initiative, that the Technical Society join with it as far as possible. This Society should be represented; we ought to be able to say some words of encouragement, and show that we appreciate that work. I move that a committee be appointed by the Chair, consisting of three members, who will, upon notification, act with any bodies that may be appointed."

Mr. Richards thereupon said:

"I am in sympathy with Mr. Manson's remarks and his views. I ventured the same suggestion in my Journal some time ago. It seems to me that we have been very selfish and very indifferent to allow this great work to go on in our midst without the slightest recognition from our Society. It is a great factor on this Coast. Perhaps our indifference is partly accounted for by the fact that the builders and designers of these ships have not thought it worth while to tell us anything about them. I concur in the fullest manner with Mr. Manson's views, and I second his motion."

The motion was put by the Chair and carried unanimously, whereupon the following committee was appointed for the purpose as embodied in Mr. Manson's remarks: John Richards, Wm. F. C. Hasson and J. H. Striedinger.

Adjourned. OTTO VON GELDERN, *Sec'y.*

TECHNICAL SOCIETY OF THE PACIFIC COAST.

SAN FRANCISCO, CALIFORNIA.

INSTITUTED APRIL, 1884.

TRANSACTIONS.

(VOLUME X. No. 12.)

NOTE.—This Society is not responsible, as a body, for the statements and opinions advanced in any of its contributed publications.

THE RED POINT DRIFT GRAVEL MINE.

By C. F. HOFFMANN, Mem. Tech. Soc.

[Read Jan. 6th, 1894.]

In starting the work of this mine the writer could find no published data upon which to base any estimates, and concluded to keep a full record during the progress of the work for future use.

The "Red Point" is a drift mine in one of the ancient lava-capped river channels of the Forest Hill Divide, Placer County, California, located at an elevation of 3,875 feet above sea-level, or 2,000 feet above the North Fork of the American River. It belongs to the Golden River Mining Co., of Paris. The channel is known as a "blue channel," from the color of the gravel.

DISCOVERY.

This channel was first discovered in the Mountain Gate Mine, at Damascus, about a mile and a quarter distant from Red Point. The Mountain Gate was originally located on a channel of white quartz gravel known as the "white channel," which the owners followed in a southerly direction into the hill for a distance of 6,500 feet, where they found it sharply cut off by a flow of lava or volcanic cement. The words "lava" and "volcanic cement" are used as commonly applied by gravel miners. The material in this section is composed of consolidated sediments from a volcanic mud flow, which have been variously described as tufts, tufas, breccias, conglomer-

ates, and cements. There is little or no evidence of a molten lava flow in this section, except perhaps on the summit, where the lava is crystalline. The bed rock, with the volcanic cement resting upon it, pitched sharply to the south. After drifting to and fro along the contact, hoping to find the continuation of the white channel, the bed rock was followed down on its pitch, and the gold found to continue as far as the exploration extended. A drift was then run into the volcanic cement, and a winze sunk 90 feet down to bed rock, disclosing what is known as the blue channel. This channel was worked up and down stream for 1,400 feet of its length, establishing its approximate course as southwesterly, or nearly at right angles to the white channel. It had not only cut away a large section of the older channel, but had worn down its bed to 90 feet greater depth. Soon after this the extension of the white channel was discovered on the opposite hillside, several miles to the south, where the Hidden Treasure Mine was located. From this point of discovery it was followed up stream into the hill to the north for a distance of 10,000 feet, here again it was cut off by the same lava flow covering the blue channel. It is this blue channel that the Red Point Mine is located upon.

The Gold River Mining Co., having secured the ground to the northeast, had careful surveys made of the Mountain Gate Mine, and also of the rim rock (contact between the volcanic cement and bed rock) exposed on the surface for a distance of 8 or 9 miles to the northeast along the Forest Hill Divide. These surveys, including levels, furnished an assurance of the confinement of the channel within the company's ground. There were no points of the rim rock low enough to permit of the escape of the channel, it was virtually hedged in. Upon the basis of these surveys a point was located and the Red Point Tunnel started to tap the blue channel.

The data here presented concern this tunnel and the developments made through it. It was driven through slate bed rock in a southerly direction, the blue channel being tapped by means of an upraise 22 feet high, started at a point 1,840 feet in the tunnel. The general features of the Forest Hill Divide are described in the State Mineralogist's Report of 1890, and the map accompanying that report is partly based on the surveys made for the purpose just described.

Appended to this paper is a reduced copy of a portion of the above map, which will show the location of the Mountain Gate and Hidden Treasure developments in the white and blue channels, and

the work of the Golden River Mining Co., from the Red Point tunnel.

THE TUNNEL.

The tunnel is 7 × 8 feet in the clear, has a grade of 3 inches in 100 feet, and when originally run had a double track for the first 100 feet, with a drain ditch in the center, and from that point on a single track with the drain ditch on one side, and switches every 500 feet. The switches and double track have since been removed as there was no further use for them.

The rails used are 16-pound steel rails, with a gauge of track of twenty inches. The air compressor is located 200 feet vertically above, and about 300 feet distant from the mouth of the tunnel, the air being conveyed through a 3-inch pipe, which, in the tunnel, has valves and blowouts every 500 feet for the purpose of ventilation. There were no other pipes in the tunnel, except a 1-inch water pipe for drilling use (at the time of running the tunnel).

After the location of the tunnel it was necessary to build a wagon-road 6,500 feet in length, leading from the summit to the compressor site, a difference in level of about 700 feet, also to bring water a distance of 2,800 feet in a 2-inch pipe to supply the works. The steepness of the cañon in which the tunnel is located made it necessary to do a great deal of grading, and to build crib work to make room for a framing yard, blacksmith's shop, etc., the cost of which is given further on under the heading of "Yards, Dumps and Trails."

Work on the tunnel proper commenced on the 2nd day of July, 1886, and 108 feet were run by hand with an average force of 6 men per day. The compressor was started on the 5th day of August, and on the 31st of January, 1887, the tunnel had reached a length of 1,552 feet. The last 1,444 feet were run with an average force of 20½ men per day. During the seven months the compressor was idle for 15½ days on account of an accident to the air valves and the cracking of a casting, making it therefore only 6½ months' work on the 1,552 feet, or an average of 234.1 feet per month, including the hand work. The two largest runs made for two consecutive weeks were 71 feet for the week ending August 28th (six days' work), and 84 feet for the week ending September 4th, or respectively 11.82 and 12 feet per day. The tunnel runs diagonally across the strike of the rock, which consist of strata of metamorphic slate alternating with sheets of diabase, diorite and barren white quartz.

The regular force of men employed (when full) consisted of

15 miners	working	8	hours	per	day.
2 engineers	"	12	"	"	"
2 drivers	"	12	"	"	"
2 blacksmiths	"	10	"	"	"
1 timberman	"	10	"	"	"

divided into three shifts and working two air drills on columns. The blacksmiths and timbermen only worked in daytime, unless on account of hard rock, it was necessary for the blacksmiths to work extra time.

COST OF SURFACE IMPROVEMENTS, PLANT AND TUNNEL.

	Total Cost.
Road.—6,500 feet long; average grade 1 foot in 10 feet; commenced May 26th, 1886; completed July 1st, 1886. Average force of men per day, 9.2; cost, including surveys and powder	$963.00
Yards, Dump and Trail.—Commenced June 21st, completed July 31st. Average force of men, 5.6; cost, including crib work, timber and powder	508.05
Boarding house, office, blacksmith shop, stable, powder house, wood shed, framing sheds, snow sheds, etc.	2,310.10
Water Works.—Log Dam, 2-inch pipe, line 2,800 feet long in ditch and covered; commenced May 30th, and completed July 30th. Average force of men per day, 2.74. Cost, including surveys, powder and pipe	604.94
Air Compressor. Erection commenced July 1st; completed with pipe line to tunnel July 30th. Average force of men per day, 5. Cost of labor	970.00
One No. 44 Ingersoll straight-line compressor, 16 × 16 × 24; one 54″ × 16′ steel boiler, complete; air tank, pump, three 3½-inch Eclipse drills and extras, freight and building 30 × 40 feet	7,819.86
Eight iron cars	1,200.00
Two tunnel horses, two team horses and buckboard	705.00
Total cost of plant	$15,080.95

ACTUAL COST

Of 1552 feet of tunnel, 7 X 8 feet, up to February 1, 1887, exclusive of management, including 43 timber sets.

	Total Cost.	Cost per Running Foot.
Total labor (pay roll)	$11,418.47	$7.36
Powder.—10,567 pounds Giant No. 2, and 325 pounds No. 1, at 26½ c., 41½ c., 10 per cent. off	2,641.64	1.70
Fuse.—39,650 feet at $5.50 per m., and caps $45	263.07	0.17

Wood.—402 cords at $2.75 delivered	$1,105.50	$0.71
Charcoal.—1,604 bushels at 20 cents, delivered	320.80	0.21
Candles.—1,760 pounds at 16½ cents, delivered	290.40	0.19
Foot plank and ties.—7,355 feet of lumber at $20 per mill., delivered	147.10	0.09
Timbers.—43 sets at 6 cents per running foot, delivered	46.76	0.03
Steel Rails.—16,640 pounds at $60 per ton	510.00	0.33
Air and Water Pipes.—3 and 1 inch at 18 cents and 5⅝ cents per foot	521.86	0.35
Horse feed	281.25	0.18
Material.—Steel, oil, tools, etc.,	693.00	0.45
Freights, at $1.25 per 100 hundred pounds	1,000.00	0.64
	$19,239.85	$12.40

With present reduced prices of powder, candles, etc., such a tunnel could now be run for $11.25 or less per running foot.

From the upraise, 1840 feet in the tunnel, the channel was worked for a distance of 500 feet down stream to the west, and for a much greater distance up stream to the east. A branch tunnel was run at the same time under the easterly extension for a distance of 1,300 feet, and two upraises made into the channel to be used as gravel chutes. The second of these is 3,040 feet from the mouth of the tunnel.

This point reached, it was apparent that the gravel was not rich enough to warrant the extra expense of a bedrock tunnel and upraises. A slope was therefore raised from the end of the branch tunnel into the channel with a grade of 1 foot in 2½ to serve as a footway for horses. The upstream work in the channel was then continued as before, but without a tunnel underneath.

THE CHANNEL.

The gravel occupies a typical river bed with all its windings, bars, islands, pot holes, branches, etc., which only differs from the present rivers in its volcanic cement capping and somewhat greater grade. Its general course is southwesterly. It has a uniform grade of about 70 feet to the mile. Its bottom width is from 75 to 650 feet, average 200 feet. There have been encountered several islands; reaching heights of 12 or 14 feet above the average bed, and three large pot holes 80 to 120 feet long and 50 feet wide, and 9 to 14 feet deep. As a rule such holes are filled with large boulders and sand, and contain no gold, but in this case two of them contained rich

gravel; one in its southerly half, the other in its northerly quarter, the third was entirely barren. These holes were all found in hard bedrock. The soft rock is generally more uniformly graded, and has a level surface. Large trees, pines and cedars, almost unaltered, are of common occurrence in the volcanic cement immediately overlying the gravel, and this fact proves that this material was delivered in the form of a mud, and not as molten lava. Pine cones (apparently *Pinus Contorta*) and small branches have been found in the gravel. No fossil bones of any kind have so far been discovered.

THE BED ROCK.

The bed rock is principally metamorphic slate, often carrying large crystals of iron pyrites, and interstratified with calcareous schists, sheets of diabase and diorite, and quartz veins. The general strike of the strata varies from N. 25° to 32° W., and the dip from 45° to 80° to the northeast.

THE GRAVEL.

The gravel consists of boulders, principally of metamorphic schists and porphyrites with a very small percentage of quartz, intermixed with small pebbles and sand, and occasionally fine particles of iron pyrites. In some places the gravel of the old water courses is loose, with very little fine material between the boulders, and the latter are often covered with iron pyrites. As a rule the gravel in the mine has a bluish color, which gave rise to the name of "blue channel," but there are places where it is nearly black or red, and evidently discolored by percolating waters. When delivered to the surface and dried it has more of a grayish color. The gravel is "free," that is, it is soft enough to be washed without crushing, although blasting is resorted to as a means of facilitating extraction. The depth of the gravel is from a few inches to 16 feet, generally 7 or 8 feet in the center of the channel, thinning out to a mere seam on the rims. It is immediately capped with the volcanic cement, which forms a fine roof to work to. The overlying cement has a depth of 500 to 1,000 feet, and is in the form of beds with intervening layers of gravel. The latter sometimes are also gold bearing. The washed and rounded boulders are often 2 or 3 feet, and occasionally 6 or 8 feet in diameter. A very characteristic boulder of this channel is striped with white, greenish and dark colored streaks. The gravel often has a glistening appearance, and is found to be coated with minute quartz crystals. Wherever this has been observed the gravel is barren.

THE GOLD.

The gold is mostly in the form of what is known as "scale gold," consisting of flakes resembling fish scales, or the scaly particles in bran. In places, however, there are streaks of coarser gold and occasional nuggets of one or two ounces weight.

Size.—A number of "cleanups" were passed through a series of sieves of different meshes to determine the percentage of coarse, medium and fine gold. They were included under the heading :

Coarse Gold.—All that will not pass a sieve of 10 meshes to the inch. There are required from 600 to 700 of the finer colors of this class to weigh one ounce, and in these are included all colors, from the weight indicated up to the largest nugget.

Medium.—The remaining part that will not pass a 20-mesh sieve. This is more scaly and uniform in size, average 2,200 colors to the ounce.

Fine.—The remaining part that will not pass a 40-mesh sieve, average 12,000 colors to the ounce.

Powder.—The remaining part having passed the 40-mesh sieve, colors too fine to count, average 40,000 or more to the ounce.

The following are the percentages by weight : *Coarse* 15.78 per cent. ; *Medium*, 48 per cent. ; *Fine*, 36 per cent. ; *Powder*, 0.32 per cent.

Value.—The gold varies in fineness (purity) from .928 to .937, and the ounce is valued at $18.90 net. The purest gold has been found where the largest streams of percolating water were encountered in the gravel breasts.

Distribution.—The distribution of the gold in the channel is very irregular. Most of the gold is found on the bed rock. In some sections, however, it is mainly in the gravel above. The richest spot in this mine was found in a layer of gravel from 6 to 12 inches above the bed rock. At this point the bed rock was hard and smooth, and the channel straight. Some of the gravel was scraped up by hand, and contained as much as 33 ounces to the pan. For two months the average yield was $7.50 per car load of 22 cubic feet. It appeared as if the gold had been carried by a freshet which spent its force at this particular place.

Again, the gold is found in paying quantities in an upper layer, from 40 to 10 feet above pay streak on the bed rock. There is one rule which applies to this channel, and perhaps to others with beds of stratified rocks. The consecutive strata having different degrees

of hardness will form riffles, so to speak, along or across the channel according to its course. Now when the gold dust strikes these riffles it is washed along them in the direction deflecting least from the course of the stream and concentrates toward the rim. If it strikes at right angles it lodges in the center, or scatters to the right and left. (See sketch, Fig. 1.)

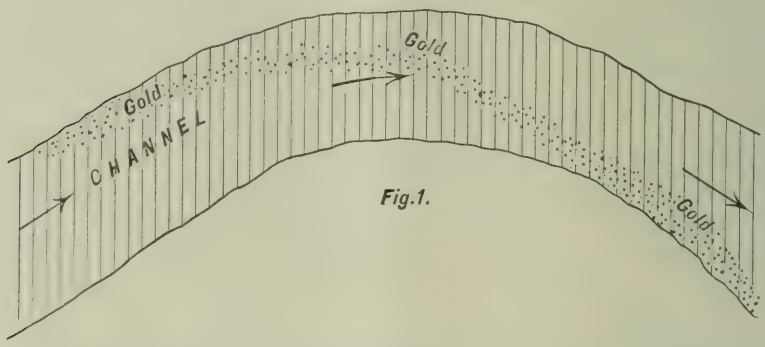


Fig.1.

This rule holds good for the main bodies of pay gravel. Of course if the bed rock is once covered it no longer governs the travel of the gold in this way, and this rule applies only to the pay streaks on the bed rock. In these main bodies the quantity of the gold again varies very much locally. It is generally found more abundant in cracks formed by the cleavage of the rock, at right angles with the strike, also around quartz veins, which are rough on the surface and hold the gold more readily, or where the slate is soft and thinly foliated. The gold dust will lodge in small pockets or pot holes and in cracks to the depth of a foot or more. The lowest rut in the channel contains very little gold, sometimes a little coarse gold, but the bulk of it is thrown on the sides or higher rock. It is also found more plentifully on the down stream side of islands and very large rocks.

SYSTEM OF WORKING.

A map of the working is herewith presented. A main gangway is run as near as possible in the lowest part of the channel, avoiding turns as much as possible. Cross cuts are run from this gangway every hundred feet, if practicable, toward each rim. They are not driven at right angles to the channel course, but diagonally across it, so as to avoid cutting too much bed rock to keep the grade down. Arriving near the rim, where the bed raises rapidly, the grade is abandoned, and the rock followed up high enough to make sure

that the true rim is reached. Generally the rim is indicated by sand and fragments of loose bed rock (float). The bed rock is so uneven and steep in places that car tracks on a higher level become necessary to facilitate the delivery of the gravel from the breasts to the cross cuts or gangway. These are about 4 feet above the normal grade, high enough to dump from one car into another. The cars running on these higher levels are of smaller size. In some places wheelbarrows are resorted to, and this makes the extraction expensive. The main gangway is kept ahead of the breasts as far as possible, and most of the breasting is done from the cross cuts and small car tracks. Blasting occurs only twice a day, at noon and 11 P. M., just before meal times. The roof being firm cement, no lagging is needed in timbering, only posts and caps are required. The posts, measuring not less than 10 inches in diameter, are placed from 6 to 8 feet apart, and sills are put under them where the bed rock is soft. Natural pillars of gravel are occasionally left along the sides of the main gangway and cross cuts, and at other points when the channel is wide. About one third of the gravel consists of boulders exceeding 5 inches in diameter, and these are not removed from the mine, but are used in building walls between the timbers along the sides of the gangway and cross cuts to give further security against flaking and caving of the roof.

VENTILATION.

Heretofore the ventilation of the mine has been accomplished by a No. 4 Baker blower run by steam power, and requiring 7.5 indicated horse power. However, quite recently a second blower (No. 4½ Baker) has been introduced. This is attached to a Pelton wheel, and will be run by water power for at least 6 months of the year. The air pipe used is 11 inches in diameter, and only one such pipe is required for ventilation, excepting where the channel is very wide. In such places a 7-inch distributing pipe is carried into the breasts, but usually the cross cuts and connections cause a sufficient circulation without such aid. The monthly cost of ventilation by steam power is as follows: (Average of six months.)

Two engineers at $3.50	$193.00
Thirty-three cords of wood at $2.87	94.71
Oil, 6½ gallons	4.60
Eighty feet of new 11-inch pipe at 46 cents	36.80
Total	$329.11

This shows for 3,064 car loads, 17 cents per car load.

TRANSPORTATION.

Four horses are needed for the transportation of the gravel, two on the day shift and two on the night shift. One extra horse is kept for reserve. One horse takes a train of 6 cars through the gangway to the chute, where the gravel is dumped. From the bottom of the chute, in the bed rock tunnel 44 feet below, the gravel is drawn in a train of ten cars, and the second horse takes it out to the dump house. The channel cars are iron dumpers of 22 cubic feet capacity. The tunnel cars have the same capacity, are also of iron, but the front ends are inclined and they are not dumpers. The latter are run out to the surface on to a self-dumping chair designed by Mr. H. C. Behr. This chair turns upon an eccentric axis, and the gravel is dumped to the washing floor 30 feet below. The driver does the dumping. Each train has a break car attached to it. The total distance from the breasts to the dump house is 6,514 feet, or nearly 1.25 miles, 3,273 feet being in the channel gangway, and 3,241 feet along the tunnel to the surface. The number of cars used in the mine at present is 30. The monthly cost is as follows: (Average of six months.)

Feed for horses	$62.50
Wages of 4 drivers, at $3.00	324.00
Wages of 2 Chinamen, at $1.75	98.00
Car wheels, oil, etc	20.00
Total	$504.50

This gives for 3,064 car loads 16 cents per car load.

COST OF LABOR.

The average cost of materials, transportation, ventilation, and management is easily calculated, but the item of labor is more difficult to determine. It varies with the width and depth of the pay gravel, with the number of Chinese employed, with the unevenness of the bed rock, with amount of work in erecting new buildings and making other improvements, and with the labor required to protect the company's property in times of heavy snows and freshets.

The results of a number of figures give the following averages: Average number of men employed daily, 58.5, (22 whites and 38.5 Chinese). Average cost of labor per man, $2.23. Average number of carloads extracted, per day's labor, $1.87.

This estimate includes all hands employed on the works, underground and on the surface.

A man breasting gravel will take out from 2.80 to 3 carloads a day, and sometimes a little more. This also depends on the depth and compactness of the gravel. As many as 220 car loads have been taken out in one day by the above-cited force.

The pay roll for six months, omitting labor already cited under headings "Ventilation" and "Transportation," shows an average of $3,169.75 per month. This gives for 3,064 car loads extracted a labor expense of $1.03 per car load.

COST OF MATERIALS

of which only yearly inventories are taken (for the year 1892):

Timbers	$931.87
Lumber	300.00
Hardware	585.18
Rails	391.90
Air pipe	342.00
Car wheels, etc	241.00
Sundries	120.93
Freight	575.47
Total	$3,488.35
On hand (estimate)	656.28
	$2,832.07
For one month	$236.00

MATERIALS USED IN ONE MONTH.

With an average extraction of 3,064 car loads.

1,191 pounds powder, No. 2, at 10 cents, (average of 6 months)	$119.10
4,800 feet fuse at $6.00 per m	28.80
1,766 caps at $5.00 per m	8.83
615 pounds candles at 10½ cents	64.57
11 gallons coal oil at 26 cents	2.86
5 " engine oil at 65 cents	3.25
1½ " cylinder oil at 90 cents	1.35
6 " lard oil at 90 cents	5.40
11 " car oil at 35 cents	3.85
131 bushels charcoal at 20 cents	26.20
3,662 pounds hay at $25.00 per ton	45.77
1,669 pounds barley at $1.80 per hundred	30.04
33 cords of wood at $2.87	94.71
Timbers, lumber, hardware, air pipe, rails, car wheels, sundries, freight, cited in the above yearly inventory	236.00
Total	$670.73

This gives, after deducting materials already entered in estimates of "Transportation" and "Ventilation," $443.41, or 14½ cents per car load.

COST OF MANAGEMENT.

The monthly cost of management, including superintendent's salary, office expenses, travelling expenses, cablegrams, expressage on gold, taxes, etc., average of six months, $649.00 or 19½ cents per car load. Total expense per car load is therefore:

Ventilation	$0.11
Transportation	0.16
Labor	1.03
Materials, etc	0.14½
Management	0.19½
Total	$1.64

PRODUCTION.

The total production during five years, from January 1st, 1888, to December 31, 1892, was 140,345 car loads, yielding $308,245.40, or $2.20 per car load. The total production of the mine has been $363.473.60 from 5,073 running feet of channel, or $71.65 per running foot.

WASHING THE GRAVEL.

The dump house, in which the gravel is washed, has a floor 31 feet below the car track. This floor slopes from the two sides toward the center, which is provided with a sluice box 16 inches wide in the bottom, and having a grade of 15 inches in 12 feet. The gravel is dumped on to this floor and washed with the stream from a three-inch nozzle under 25 feet pressure.

The line of sluices, drops, etc., is as follows (beginning at the washing floor): 157 feet sluice boxes, vertical fall or drop, 30 feet; 11 feet ground sluice, 36 feet sluice boxes, 10 feet drop; 24 feet ground sluice, 182 feet sluice boxes. After this the gravel washes down a steep cañon with several falls and short sluices for a distance of 1,500 feet, then passes through a double flume and over an under current.

The upper sluice is nominally divided into sections, the upper 59 feet being called the "Upper Sluice," and the lower 98 feet the "Lower Sluice." The next two sluices of 36 and 182 feet are called the "Cañon Sluices," and everything below them is credited to the "Tailings."

In the "Upper Sluice" no quicksilver is used, and it is cleaned up every three days, or oftener if the gravel is very rich. All the other sluices are supplied with quicksilver. The "Lower Sluice" and

"Cañon Sluices" are cleaned up at the end of each month, and the "Tailings" once a year.

The riffles used in the sluices are made of wooden strips 3 inches high by 1½ inches thick, topped with strap iron half an inch thick. In the "Upper Sluices" they are 6 feet long, which is a convenient length for frequent handling. In the "Lower Sluices" they are 12 feet long. Six of these riffles fit into one sluice box, and leave an inch space between each. Every 12 feet a Hungarian riffle (an iron grating) is introduced to disturb the current of the water. In the "Cañon Sluices" ordinary riffles, wooden blocks, old car wheels, and cobble stones are used, all forming good gold catchers.

The following percentages of the total yield are obtained from the different sluices, etc. (Taken from an average of 12 months):

Upper Sluice (without quicksilver)	82.48	per cent.
Lower Sluice (with quicksilver)	3.89	" "
Cañon Sluice, 36 feet " "	2.86	" "
" " 182 feet " "	3.24	" "
Tailings " "	5.72	" "
Panning Tub " "	1.63	" "
Blowings (black sand) " "	0.18	" "
	100.00	per cent.

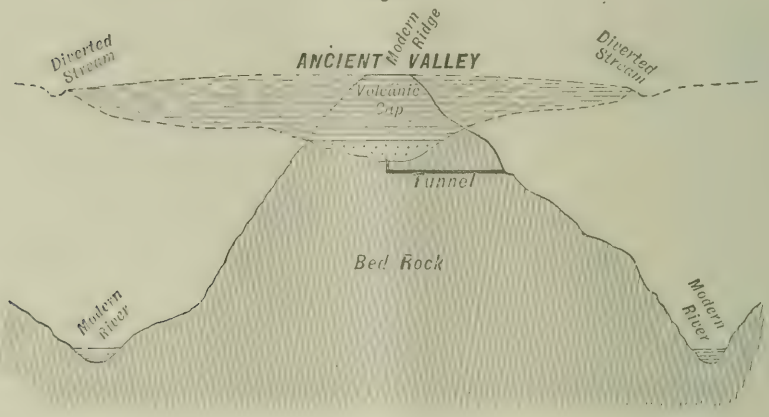
DISCUSSION.

Before reading the paper Mr. Browne said:

"The drift mine, of which Mr. Hoffmann's paper treats, is in one of the ancient river beds of the westerly flank of the Sierra Nevada. These are found in a striking topographical position, occupying the summits of the modern ridges, high above the present streams. This apparently anomalous position is due to the displacement of the ancient streams by lava and mud flows from volcanic eruptions in the high Sierra. These flows filled the old river beds and diverted the streams, which cut new beds to gradually greater and greater depths, leaving eventually portions of the gravels of the ancient rivers, with their volcanic caps to form the modern ridges, as shown in the following cross section. (Fig. 2).

The gold is contained mostly in the bottom layer of gravel under the volcanic cap. The method of mining is by driving a tunnel in from the hillside to tap the bed and drain off the water, and to serve as a tramway for delivery to the surface. The auriferous gravel is

Fig.2.



excavated, carried to the surface, and dumped on to a sloping floor at the mouth of the tunnel, and washed thence through a line of sluices, provided with riffles to catch the loose particles of gold—the gold dust.

Much of the data furnished by Mr. Hoffmann cannot be found in a published form, and is of special value to engineers in making estimates for similar enterprises."

After reading the paper Mr. Browne added:

"Aside from the figures giving working results, Mr. Hoffmann has observed several occurrences which I have not heretofore heard described, and which appear to me as having special interest. These are particularly: the poverty of the gravel where the boulders are coated with microscopic crystals of quartz; the effect of the strike of the natural riffles relatively to the course of the river in determining the position of the pay streak; and the greater the purity of the gold, where large quantities of percolating water were encountered in the gravel breast.

This latter observation indicates that the gold particles have undergone a slow process of purification by prolonged washing.

There is no doubt in the minds of those most familiar with the occurrence of auriferous gravels that the gold dust was derived from the degradation of the gold bearing quartz veins. But it is a matter of common information that the placer gold is purer than the gold in the quartz veins, and this fact gave rise to disputes concerning its origin. It was asserted by some theorists that the greater purity showed a difference in origin. However, the evidences of the deriva-

tion of the placer gold from the quartz veins are conclusive, and it remains only to explain the greater purity. I have for some time past been collecting information on this subject, and find the following averages from a large number of our California mines: Gold taken from placers, .890 fine; from quartz veins, .820 fine. The other constituents are mainly silver, partly baser metals.

The theory has been advanced, that the silver and baser constituents when exposed to the action of air and water are partially oxidized and dissolved, while the gold remains unaltered. In this way there results a purification of the outer film. The aggregate effect on the fine particles would be greater than on the large nuggets, and in fact the greater purity of the fine dust, and of the outer films of nuggets, is well known to dealers in placer gold.

Mr. Hoffmann tells me that, in the Red Point mine, in passing from a comparatively dry into a very wet section the purity of the gold dust always increases, generally from .003 to .005, or say one half per cent. Though something of the sort might have been anticipated, it is the first time I have heard of its being actually observed."

MR. MANSON.—"Aside from the technical interest that the mining engineer would take in this paper, there is a great deal in it and in Mr. Browne's explanation of the occurrence of these two sets of river channels and the obliteration of one set with the lava overflow, that interests the geologists.

I have had occasion to examine the western slope of the Sierras from a few dozen miles south of the point so interestingly described in this paper, to Mt. Shasta, and the western slope of the Rocky Mountains in Eastern Washington, Idaho and Montana. In that area, embracing parts of California, Washington, Oregon, Idaho and Montana, there are about 150,000 square miles, which are or have been covered with lava. Towards the northern edge, up in Montana, Idaho and Washington, the lava is from half a mile to a mile and a half thick, and is of dense basalt. Towards the southern edge or limit it appears to have degenerated, or certainly decreased in hardness as well as in thickness, and in some instances it is a mud lava that can be picked and handled without any very great trouble. In the Sierras the first set of river channels appears to have been formed during the period of denudation that followed that upheaval.

This denudation of portions of the Sierras amounts to about two miles in thickness, and in some instances to more. As that two miles was denuded from the western slopes of the Sierras, which was a line of lighter crust in process of upheaval, the amount of denuda-

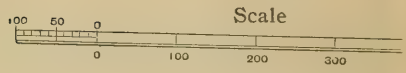
tion lightened the load upon the crust and destroyed the state of isostatic equilibrium that the crust is always in. This caused the crust to upheave more. The denuded materials transported down the sides of the Sierras by water and gravity, were deposited in the great valley of California, and this already in process of sinking was more heavily loaded. The additional load on the sinking area caused it to settle still further. So that denudation acted in a double way to accentuate the difference of elevation between the valley and the mountains; that is, the continuous denuding of the one caused the building up of the other. At the same time the process caused the valley to settle more, and the mountains to upheave to a greater extent. Towards the latter part of the Tertiary, and probably running well into the Quaternary Period, the process of denudation seems to have been interrupted by this lava flow, as Mr. Browne described, and a new set of river channels started in. In most instances these ran across the others, and in the modern rivers the richest deposits have been found just below where they had cut through the ancient river channels. The gold in the modern channels being the result of a double set of concentrations, first in the denudation and the filling up of the ancient river channels, and finally in being re-concentrated in the modern rivers, leaving the enormously rich deposits that the forty-niners worked with such good results.

I regard this paper as an exceedingly valuable one, because it describes mining as a business enterprise. Mining in the early days, and even up to 1877, was largely a gambling operation; after the mine was located the stock was put on the market, and it made but little difference whether the mine was valuable or not. So the mines were not systematically worked, and in many of the old river channels there are wonderful deposits yet, and, I believe, that the mining engineer and the geologist have before them a field of wonderful fertility in following up these river channels, not only in the high Sierras, where they are covered by the lava caps, but by following them down into the plains below the level of the present alluvial surface of the valleys, and also in the drift mines well under the surface of the present rivers. And I believe that this is going to be a line of mining which will be followed very largely in this country, and that projects of this nature will ultimately prove very attractive to capitalists."

Mr. Striedinger.—" Mr. Hoffmann's paper fills, in a masterly manner, a long-felt gap in the literature on gravel mining. How

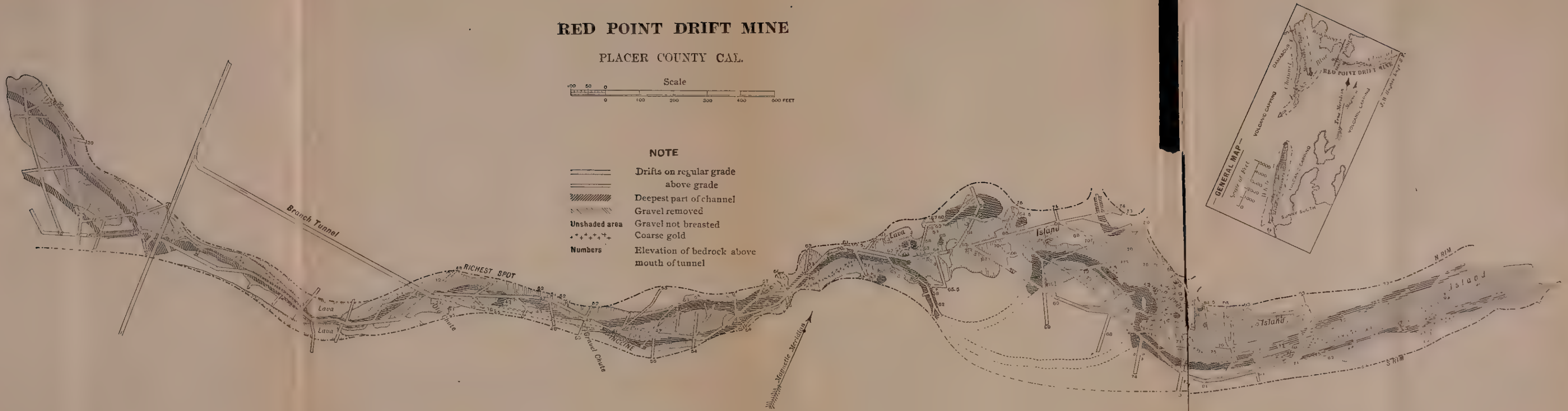
RED POINT DRIFT

PLACER COUNTY CA



NOTE

- Drifts on regular grade
- above grade
- Deepest part of channel
- Gravel removed
- Unshaded area — Gravel not breasted
- Coarse gold
- Numbers — Elevation of bedrock at mouth of tunnel


RED POINT DRIFT MINE
PLACER COUNTY CAL.
Scale
0 100 200 300 400 500 FEET
NOTE
Drifts on regular grade
above grade
Deepest part of channel
Gravel removed
Unshaded area Gravel not breasted
Coarse gold
Numbers Elevation of bedrock above mouth of tunnel
Branch Tunnel
RICHEST SPOT
Lava
Island
Gravel Chute
Magnetic Meridian
N. RIM
S. RIM
GENERAL MAP
RED POINT DRIFT MINE
VOLCANIC CAPPING

thoroughly and economically the exploitation of the Red Point Drift Mine is carried on under his superintendence is shown by this abstract from his reports.

Mr. Browne has not mentioned the fact that he and Mr. Hoffmann executed the original survey of this mine, and subsequently located the tunnel, which, by crossing the ancient river channel about 20 feet below its deepest point, causes a perfect drainage of the underground workings. There are very few drift mines which are so well laid out.

Drift mines are not confined to the Pacific Slope of our Sierra. Not quite a year ago I discovered some drift mines on the westerly foot hills of the Andes, near Barbacoas, Republic of Colombia, S. A. Drier drift mines than the "Red Point" are usually opened by means of inclined shafts with drifts extending from their bottoms.

MR. BROWNE.—"The deep drain tunnel is necessitated by the amount of water contained in the channel. In the Red Point this amounts to 35 or 40 miner's inches, in the Mountain Gate and Hidden Treasure to 40 inches each, in the Mayflower, further down the ridge, to 75 inches. If mined through deep shafts the handling of such quantities of water would eat up the profits.

There are a series of drift mines in the Harmony Ridge, near Nevada City, however, where the gravel is almost dry, and the work there is most profitably carried on, as stated by Mr. Striedinger, through inclined shafts. The advantage of the inclined shaft is that it is shorter, and it may be run down on the rim rock until the bottom is reached, and it is not necessary to rely upon a vague estimate of the depth or position of the channel bed, as might be the case in driving a tunnel. But it should be borne in mind that every miner's inch means about 70 tons of water per 24 hours, and that the expense of lifting a very few inches will often amount to more than the expense of hoisting the total amount of gravel extracted. For example, the Mayflower mine delivers about 140 tons of gravel per day, and there runs through its drain tunnel nearly forty times this weight of water.

REGULAR MEETING, JANUARY 6, 1894.

PROCEEDINGS.

MINUTES.

Called to order by President Grunsky.

The minutes of the last regular meeting were read and approved.

Mr. E. H. Merrill was elected to membership, while the name of A. H. Koebig was withdrawn at his own request, and the ballot thereupon not considered.

The following names were proposed for membership:

Thomas W. Brooks, Technologist, of San Francisco; proposed by H. C. Behr, H. Vischer and D. C. Henny.

F. A. Koetitz, Civil Engineer, of San Francisco; proposed by C. E. Grunsky, Marsden Manson and Otto von Geldern.

The Nominating Committee, consisting of Ross E. Browne, Chairman; Marsden Manson; Hermann Kower; Julius H. Striedinger and H. C. Behr, submitted the following ticket for the election of officers for the ensuing year:

President, C. E. Grunsky.	Vice-President, Geo. W. Dickie.
Secretary, Otto von Geldern.	Treasurer, W. C. Ralston.

DIRECTORS:

Frank Soulé.	W. F. C. Hasson.	Geo. E. Dow.
Henry S. Wood.		J. Ch. H. Stut.

Mr. Ross E. Browne thereupon read a paper prepared by Chas. F. Hoffmann, entitled "The Red Point Drift Gravel Mine," which proved to be a most interesting addition to our technical literature, by reason of its extremely valuable statistical data connected with the operation of that particular mine. The paper was discussed by members present.

The President appointed as judges of election, in accordance with Article II, Section 2, of the By-Laws, Messrs. H. C. Behr and Geo. F. Schild.

Adjourned.

OTTO VON GELDERN, *Sec'y.*

ANNUAL MEETING, FEBRUARY 2nd, 1894.

[Adjourned from Friday, January 26th, 1894.]

PROCEEDINGS.

MINUTES.

In the absence of the President, Director Geo. W. Dickie filled the chair.

The minutes of the last regular meeting were read and approved.

Messrs. Thomas W. Brooks and F. A. Koetitz, having been duly elected by ballot, were declared members of the Society.

In accordance with Article II, Section 2 of the By-Laws, the ballot was declared open for the election of officers of the Society for the ensuing year. The appointed judges counted the votes cast and reported the result to the Chair, who announced that all the ballots constituted one unanimous vote for the ticket as proposed by the Nominating Committee.

The officers elect are :

President, C. E. Grunsky.	Secretary, Otto von Gelden.
Vice-President, Geo. W. Dickie.	Treasurer, W. C. Ralston.

DIRECTORS :

Frank Soulé.	W. F. C. Hasson.	Geo. E. Dow.
J. Ch. H. Stut.		Henry S. Wood.

The Secretary thereupon submitted his report, which was accepted and approved.

REPORT OF THE SECRETARY FOR 1893-4.

I have the honor to submit to the Society, through its Board of Directors, the following report of its condition and progress during the past year.

The present total membership is 218, as follows :

Honorary members	3	Juniors	4
Members	198	Associates	13
		Total	218

Of these 137 are resident, and 81 non-resident members. A geographical distribution places in

San Francisco and vicinity	137	Ohio	1
Other parts of State of California	47	Oregon	3
Arizona	3	Utah	1
District of Columbia	3	Washington	3
Idaho	1	Africa	3
Illinois	4	England	1
Massachusetts	1	Hawaii	1
Missouri	1	Mexico	1
Nevada	4	Samoa	1
New York	1	South America	1
		Total	218

Professionally divided, there are :

Architects	4	Mining Engineers	23
Builder	1	Naval Architects	2
Chemists	4	Navigator	1
Civil Engineers	82	Professors of Universities	10
Draughtsmen	3	Scientists	2
Electrical Engineers	6	Student	1
Instrument Makers	2	Surveyors	14
Marine Engineer	1	Technologists	5
Manufacturers	3	Topographer	1
Mechanical Engineers	44	Of various callings	7
Military Engineers	2		
		Total	218

During the year 1893 the Society added to its membership list the following :

Honorary Member	1	Juniors	2
Members (1 reinstated)	19	Associates	2
		Total	24

Professionally divided these admissions are :

Civil Engineers	10	Navigator	1
Electrical Engineers	3	Surveyors	3
Mechanical Engineer	1	Technologists	2
Mining Engineers	2	Topographer	1
Naval Architect	1		
		Total	24

Membership of the Society in January, 1893 :

Members and Associates	236
Admitted in 1893	24
Total on membership list in 1893	260

Loss in 1893 (including January, 1894):

Deaths	3	Suspensions	24
Resignations	15		
		Total	42
Present membership	218	Decrease in 1893	18

Deaths during the year:

P. J. Flynn, Civil Engineer.....Los Angeles, Cal.
William Praun, Architect.....San Francisco, Cal.
Chas. A. C. Duisenberg, Merchant.....San Francisco, Cal.

Resignations during the year:

MEMBERS:

Edgar H. Booth.	B. McIntyre.	Edward A. Rix.
Geo. B. Birrell.	Fred'k T. Newberry.	Hadwen Swain.
W. R. Eckart.	Thomas Price.	Lewis Tasheira.
Alexis Janin.		

JUNIORS:

E. K. Hopkins.		Jas. T. Ludlow.

ASSOCIATES:

Dr. H. W. Harkness.	Dr. Franz Kuckein.	Harold Wheeler.

Suspended for non-payment of dues:

Members	17	Associates	6
Junior	1		
		Total	24

The apparent loss of so many members, is not a real one. It is a fact that about twenty members had been carried on the list for the last three years, who had forfeited their membership long ago. At the expiration of 1893 it was ordered that every member who had been asked for the payment of his dues, being in arrears over twelve months, and not responding by a remittance, be dropped from the list. This causes what appears to be a heavy decrease in 1893, when in reality the membership has been growing from month to month. The Society now has 218 paying members, which was not the case in the beginning of the year, although the list then showed a total membership of 236.

Number of regular meetings held during the past year	12
Number of papers read and discussed	15
Number of Directors' meetings	11
Number of special meetings	2

Papers were published in the printed Proceedings of the past year on the following subjects:

An Experience with a 24-Inch Gas Main.
Some Problems of Municipal Engineering.
Electric Transmission of Power Long Distances.
Photographic Topography.
Are California Homes as Healthful as they should be?
Some Problems in Pumping Fluids.
Inter-Ocean Ship-Canal Communication by the American Isthmus.
Notes on Artesian Water, and the Effect of Irrigation on Sub-Surface Water in the San Joaquin Valley.
Use of Coal Oil in Steam Boilers.
The Existing State of the Fluid Fuel Question.
Country Road Construction.
Effect of Curves in Pressure Pipes upon the Required Support.
Note on the Duty of the California Wet Crushing Stamp Mill.
Impressions of a Mechanical Engineer at the World's Columbian Exposition.
The Red Point Drift Gravel Mine.

These papers appeared from month to month in the Society's Bulletin, and were mailed in exchange for a number of the most prominent technical publications both at home and abroad. The Transactions have a wide circulation, and are sought after by many literary and professional men, for both perusal and republication.

The following are the contributors during the past year:

J. B. Crockett.
Professor Charles D. Marx.
W. F. C. Hasson.
E. McCollough.
M. Manson.
J. Richards.
N. J. Manson.
C. E. Grunsky.
Wm. A. Doble.
Admiral Selwyn.
Julius H. Striedinger.
Otto von Geldern.
D. C. Henny.
Luther Wagoner.
Geo. W. Dickie.
Chas. F. Hoffmann.

Respectfully submitted,

OTTO VON GELDERN, *Sec'y.*

The Treasurer's report, approved by the Finance Committee, was read and, upon motion, adopted.

TREASURER'S REPORT FOR 1893.

To the President and Directors of the Technical Society of the Pacific Coast:

GENTLEMEN :—I have the honor to make the following detailed report of collections and disbursements of the Society for the past year.

RECEIPTS.

Received from dues	$1,634 00
" " admission fees	180 00
" " sale of "Transactions"	27 50
" " sale of "Certificates"	21 00
" " rent of desk room	120 00
Total	$1,982 50

DISBURSEMENTS AS PER VOUCHERS.

Secretary's services (13 months)	$ 325 00
Room and Hall rent	525 00
Printing	360 40
Engraving	235 90
Typewriting	38 75
Reporter	71 00
Collector	139 80
Janitor and Elevator Man	46 00
Binding "Transactions"	18 00
Postage and expressage	163 49
Furniture, etc	7 00
Coal, Towel and Gas Companies	28 20
Taxes and Insurance Policy	6 10
Stationery	17 74
Total	$1,982 38

ACCOUNTS RECEIVABLE.

Monthly dues (to January 1st 1894)	$690 75

ACCOUNTS PAYABLE.

Geo. Spaulding & Co	$451 30
The Industrial Publishing Co	364 97
Total	$816 27

SUMMARY.

Collections to Jan. 15th, 1894	$1,982 50
Disbursements to Jan. 15th, 1894	1,982 38
Cash on hand	$ .12

GEO. F. SCHILD, *Treasurer.*

Approved by the Finance Committee :

L. FALKENAU, *Chairman.*

San Francisco, Jan. 19, 1894.

The Secretary was instructed to distribute a circular letter to al members requesting that a year's dues be paid in advance, from January 1, 1894, to January 1, 1895, in order to meet the indebtedness of the Society to the printers for the published "Transactions."

The Treasurer's report shows that the only outstanding liabilities are the publisher's accounts, and that these might be readily met by a prompt payment of dues. An earnest appeal was made to give this matter the fullest attention, and to retain for the Society that high-standing to which its purpose and its labors so justly entitle it.

Adjourned.

JULIUS H. STRIEDINGER,
Acting Secretary.

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